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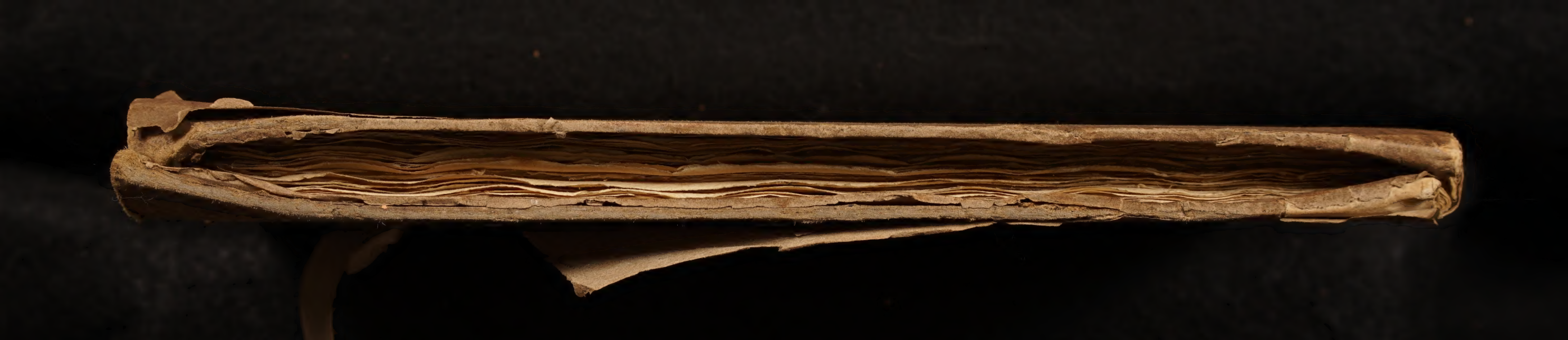

To
Reverend Thom.s Rackett
With the Author's
sincere regards.

AN INQUIRY

INTO

THE MEANS WHICH HAVE BEEN TAKEN

TO PRESERVE

THE BRITISH NAVY.

AN INQUIRY

INTO

THE MEANS WHICH HAVE BEEN TAKEN TO PRESERVE

THE

BRITISH NAVY,

FROM

THE EARLIEST PERIOD TO THE PRESENT TIME,

PARTICULARLY

FROM THAT SPECIES OF DECAY,

NOW DENOMINATED

DRY-ROT.

BY JOHN KNOWLES,

SECRETARY TO THE COMMITTEE OF SURVEYORS OF HIS MAJESTY'S NAVY.

Omnia orta occidunt, et aucta senescunt.—SALLUST.

LONDON:

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1821.

TO

THE RIGHT HONOURABLE

ROBERT, VISCOUNT MELVILLE,

BARON DUNIRA,

FIRST LORD COMMISSIONER OF THE ADMIRALTY,

This Work

IS, WITH HIS PERMISSION,

INSCRIBED AS A MARK OF THE SINCERE RESPECT AND GRATITUDE OF

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ERRATA.

Page 6, line 24, for *as five is to seven*, read, *as seven is to five.*
39, note, line fifth, for *brick*, read *bricks.*
40, for CHAPTER III., read CHAPTER IV.

Note.—At page 102 of this work, it is stated, that the method of mooring ships from their ports, " was done at the recommendation of Mr. Hookey :" it is to be remarked, that the merit of the plan has been lately found to be due to Mr. Hemmans, late Master-Attendant of Chatham-yard, who so moored the Ariadne of twenty guns in the river Medway, in May 1810.

PREFACE.

To naval and commercial countries, there is no object of greater importance than the preservation of their ships. But to Great Britain in particular, who has long claimed and enjoyed the sovereignty of the seas, and a great proportion of the trade of the world, this is a subject on which her vital interests depend. Sir Walter Raleigh has justly observed, "that whoever commandeth the sea, commands the trade; whoever commands the trade of the world, commands the riches of the world, and, consequently, the world itself." The command of the sea is not, however, to be obtained by the number of our ships, or the skill and courage of our seamen alone; it depends also upon the condition and fitness of the vessels which they navigate, and the preponderance of trade is preserved

not by enterprise only, but by conducting commerce in the most efficient manner, and on the most economical principles. The strictest attention ought then to be paid, to extend the durability, and improve the state and condition, of our royal and mercantile navies.

Until recently, the theoretic construction of ships has not been cultivated or considered, in this country, a matter of sufficient importance, and to this may be attributed the practice of copying or imitating the lines of those constructed by foreign nations. While the Dutch possessed and encouraged Witsen,—the French, Bouguer, Du Hamel, Clairbois, Borda and Romme,—the Spaniards, Juan,—the Germans, Eüler,—and the Swedes, the celebrated Chapman; the English neglected the only work which they possess on this subject, that can lay any claim to science*, and suffered its author, whom tradition represents to have been a man of the most amiable manners and correct conduct, to live and die a working shipwright in Deptford-yard.

---

* *A Treatise on Ship-building and Navigation*, by MUNGO MURRAY, published in 1754.

It is due to the illustrious name of Spencer, to state, that the dawn of science in our dock-yards arose with the naval administration of the present Earl. Knowing its general importance and influence over the useful arts, he sought for scientific men, whom he encouraged and promoted; and was the first who introduced therein, the most useful machinery, (particularly the steam-engine,) in aid of manual labour.

Within the last eleven years, a school for naval architecture has been attached to the college at Portsmouth; here the students not only receive an education which fits them to attain the theory of their art, but are also instructed in practical ship-building. This academy has, by instilling education and promoting emulation, already produced several young men of superior talents and attainments; and it is to be hoped that their ardour may not be damped; but that the encouragement will be extended to them, which has hitherto, in this country, been withheld from those who have endeavoured to promote the difficult but useful science of constructing ships.

In the proportion that theoretic construction has

been neglected, the practical art of building has been encouraged ; and hence it is, that the workmanship in British ships has been equal, if not superior, to that of most of those built in any part of Europe. But, for the want of principles, little of alteration or improvement was for many years introduced in the disposition of the materials, or connexion of the several parts, so as to increase the strength of the vessels. Within the last ten years, a new system has been invented and introduced by Sir Robert Seppings, which has given to our ships of war, great additional strength to resist the effects of the waves, is likely to be conducive to their durability, and to ensure the safety of the mariners.

From the jealousy incident to human nature, in properly appreciating and applying the inventions of others, or the indolence of the mind in not bringing itself to examine new methods or combinations, these improvements, while they have been eagerly grasped by foreign nations, are but slowly introduced in the ships of our merchants, and, with an apathy hardly to be credited, are totally neglected by the first trading company in Europe. Although ignorance of their application, and bigotry to old customs, may for

a time, prevent their introduction, the evidence of their advantages must in the end prevail.

From the earliest period of our naval history, measures have been taken and experiments tried by the government to ensure or prolong the durability of timber, before and after it is worked into ships; many of these were concealed from the public at the time they were practised, gradually became disused, and at length forgotten; and garbled or incorrect statements have been given in books as the results of others, to support particular hypotheses entertained or adopted by their authors. In the present work, care has been taken to give, not a part, but the whole of the facts as far as they can be ascertained; to render to every one what appears to be his due; and to strip the results, as much as possible, of prejudice: and in order to make the work complete, details have been given (chiefly in notes,) of the practices of foreign countries to attain the same ends. Although sedulous industry has been employed to collect the several experiments, and it is to be hoped that the reader will consider that much has been got together, yet it is to be feared, in the great mass of papers it was necessary to consult, that some may have escaped observation.

It is proper to remark, that with some few exceptions, the experiments which were tried in this country, or the facts that occurred earlier than the year 1661, have been quoted from works before the public, the authorities, however, in such cases are always given; but the details of those tried since that period, rest upon the foundation of official documents. The records of the Navy-Office may be considered to commence with the year 1661, as prior to that date, the business of the navy was conducted by the members of the Board at their own houses; hence it is, that so many manuscripts relating to the early period of the navy, are to be found in private collections. The thirteenth article of the regulations, dated 16th January 1661, which were sent by James II., then Duke of York and lord high admiral, for the governance of the Navy-Board, may be quoted for this fact*.

---

* 13thly. "They are for the more benefit of the subject to live as near together as conveniently they can, and appoint and publish certain and known times of their meetings at the Navy-Office twice every week at the least, to hear, determine, consult, and advise, upon all affairs and causes whatsoever, recommended by the lord high admiral to their care, or otherwise proper to their power and trust. And for the more easy and methodical carrying on his Majesty's service, (the late enlargement of the Navy-Office permitting it,)

The concealment under which most of the experiments that have been tried for the preservation of his Majesty's ships, have been veiled, occasions persons almost daily to propose measures for that purpose, which have been before carried into effect, and found to fail. As this work will detail not only successful, but also unsuccessful, experiments, it is to be hoped, that while it may contribute to prolong the duration of our merchant ships, that it will also prevent the man of science from wandering in the maze of speculation, when there is the sure guide of experiment.

It remains to acknowledge obligations to authors, and at the head of these stands deservedly Du Hamel: all the experiments on timber which have been made in this country, have been carefully compared with those carried into effect in France, and which are detailed in those excellent works *Exploitation des Bois*,

---

the comptroller, surveyor, and clerk of the acts, are to keep distinct offices within the Navy-Office, where they are to keep all transactions belonging to their particular duties, methodically digested in books, that so the several officers, as they shall have occasion, may the better inspect the transactions of each officer, relating one to the other; and they are also to meet all convenient times and seasons of the year, in all or any of his Majesty's yards, to transact all affairs proper to each yard, and take an account."

and *Transport des Bois*, books which may always be consulted with benefit by those who wish to gain a knowledge of the different qualities of wood. It would appear invidious to notice any one in particular, of the many treatises which have been published on the Dry-Rot; and if it should appear that there are in the chapter on that subject, observations which have already been before the public, it is but justice to mention that the author is acquainted with almost all the persons who have written thereon, and has made it a point, to communicate his views of the nature of the disease, and the result of the experiments that have been tried for its prevention and cure; so that, most probably, he is only redeeming his own.

The state and condition of the navy is a subject that cannot be too deeply studied, or too carefully attended to in this country; for whatever may be our political situation or connexion with the several Powers on the Continent of Europe, England should always recollect, that ships are her surest defence, for "her rampart is the sea."

AN INQUIRY

INTO THE MEANS WHICH HAVE BEEN TAKEN TO PRESERVE

THE BRITISH NAVY.

CHAPTER I.

ON THE PROPERTIES AND QUALITIES OF TIMBER.

THE extensive usefulness of timber, contributing as it does to most of the conveniences, and many of the luxuries, of life, has naturally excited the attention of all nations, in all ages; and the inquiries of philosophers have been directed to discover, not only the properties of the several kinds of wood, but also the means which nature employs to bring about the production and increase of trees. In this, however, their skill has been baffled; as the veil has not been removed, nor is it probable that that, which has been so long a secret, will ever be revealed to man. Although these inquiries have not been successful, yet they have been productive of much good, as they have led to the trial of experiments, from which facts have been deduced and opinions formed, as to the proper seasons for felling, the best mode of protecting and treating timber, designed to be employed in works, belonging to civil, military, or marine architecture.

The strength of the vessels, or as they are generally termed, fibres, and durability, are the characteristics of good timber, and make those sorts which possess these properties, so valuable and useful in works of art. However well an edifice may be planned, or the work executed, if the materials of which it is composed do not possess these requisites, the architect's labour has been in vain, for its early destruction is inevitable.

As oak is the wood generally employed in building and repairing European ships, and as this work treats only of naval affairs, it is intended to confine the observations chiefly to that timber. The oak-tree has been denominated the king of the forests, and was held sacred, probably on account of its beauty or superior quality, or from mystic rites being performed under the shadow of its branches, by the Greeks, Romans, Gauls and Britons; it thrives in most of the countries of Europe. Although much importance has been attached by some to a selection from the different sorts, of which it is said Boerhaave had seventy in his botanic garden, as to the quality of their timber; yet it is believed that this depends more upon soil, climate, and exposure to the influence of the wind and sun. If the soil on which they grow be favourable, such as a stiff loamy earth, or clay, rather dry than wet, the oaks of the southern parts of Europe are preferable to any others; those of Provence, the Italian and Turkish sides of the Adriatic sea, have long been esteemed for their superior quality; with these, aided by supplies from Corsica, the ships at Toulon have been built, which are considered to exceed in durability all others constructed of oak. But in these

countries the oaks are not of an uniform quality; the low marshy grounds produce trees quick of growth, the grain of which is large and open, the timber consequently weak, and subject from the alternations of the seasons to rapid decay; this is called by some, oak *cerris*, by the French *(chêne gras)* fat oak. As the hard timber is subject to split and twist, and therefore not proper for planking ships, this kind is used for that purpose; but it is acknowledged to be decidedly inferior to that grown and cut in Poland, which is generally known by the denomination of Dantzic or North-country oak plank.

In those countries where the oak is indigenous, it is an acknowledged fact, that the higher the temperature of the climate, the better the wood; but the trees, if the produce of high lands, are considerably less in size.

The American oaks, with the exception of the live oak *, *(quercus virens,* or *semper virens)* are very inferior to those grown in any other country; the French, when they had possession of Canada, and this country within a few years, have imported large quantities of the oak, which goes under the denomination of white oak, *(quercus alba)*; the rapid decay of this timber, and injury to that of a better quality with which it came in contact, have been the consequences. The American red oak, *(quercus rubra)* is still more inferior; and there are but few instances

* The Floridas produce a large quantity of the live oak, which is superior to what grows in the higher states; which renders the possession of this country of so much importance to America. This wood appears, from a late examination of some worked in the American frigate Essex, to be nearly incorruptible; of 507 pieces which had been in the ship twelve years, six only were defective.

where either kind have remained perfectly sound for more than five years. Upon a close inspection, small yellow spots are discernible upon the oak from Canada; these are the sure forerunners of early decay.

The stems of trees are subject to many defects; arising from the quality of the soil on which they grow, from accidents occasioned by the wind, from great age, or by the severity of the weather: the two first are frequently the cause of the heart-shake and cup-shake, and from the two latter arise other interior defects. As the middle of the stem, (near the *corona* of Dr. Hill,) and that part nearest the root, is the wood that is the oldest; it is probable that the juices, as they approach the centre, become more and more inactive, and in old trees, as the vessels lose their elasticity, they stagnate, become putrid, and the wood decays.

The severity of winter, in cold climates, frequently injures the outer layer of alburnum*, vulgarly called sap, or sap-wood; this never recovers its elasticity, but in process of time becomes covered with a layer of good wood; this defect, which is called a vein, is very frequent in the oak which grows single, and exposed to the frost, on the shores of the Baltic, and may be often observed in the board called wainscot, which is cut therefrom; if plank having this vein be used on the bottoms of ships, no defect is more detrimental, as the soft spongy sap-wood by absorbing moisture, occasions the decay of the outer and inner layers of the heart, by which it is enclosed.

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* The terms alburnum, blae, sap, and sap-wood, are synonymous.

Timber is subject to other defects, some is said to be foxy, some doaty, and other pieces quaggy; the first is such as has a red colour, but more particularly so in the centre of the tree; this is occasioned generally by the timber growing upon a bad soil, and it is also very common in such trees as have shot from the old stools of those which had been felled, but their roots not grubbed up: much of the oak timber which grows in the north of England is subject to this defect, hence the chief objection to north-country built ships. So well aware were our ancestors of the quick decay of that sort of wood, that the shipwrights' company * was founded, as stated in the charter, in consequence of the "Navy being so slenderly and deceitfully built, as well as our own ships and barges, as also other ships, boats, pinnaces, and like vessels of our merchants, and other our subjects, used in continual service and traffic, are made, and wrought to the great loss, danger of us and our said subjects, and also of the great, needless, and wasteful charge and expenses which we do from time to time bear, in building and rebuilding of our own ships and pinnaces." They were particularly instructed to take care at their monthly visitations, to order "sappy or *red-wood* to be removed," and the charter proceeds in these words: "We do hereby, for us, our heirs, and successors, strictly prohibit and

* This company, was founded by King James I., on the 22d April 1605: it was chartered the 6th May, 1612, and was denominated, "The master, warden, and commonalty of the art or mystery of shipwrights of Redriff, in the county of Surrey." They were empowered to make laws, impose fines, and punish the mutinous by imprisonment; the draughts of His Majesty's ships were approved by this company, which consisted of a master, three wardens, and sixteen assistants.

restrain these to be used, in, or upon any ship or other vessel." Doaty-timber is such as appears stained with yellow and black spots; although this defect is to be found in some oaks, it is more common in beech-trees; wood with such an appearance being in fact decayed, should never be put into any building. Quaggy-timber is that, which is heart-shaken, and generally proceeds from its growing on a loose sandy soil; and the cup-shake, arises from the effects of frost, or from high winds. There are other defects to which timber is subject from having been improperly lopped while growing in the forests, a practice which demands the severest reprehension.

Good oak is to be found in some parts of all the counties of England, but that which grows in Sussex and in Kent, is preferable to any other. Wales produces trees usually of small dimensions, but the wood is hard and good; they are subject to trifling defects from lopping, (being chiefly planted in hedge rows,) but when the defective parts are removed, and pieces put into the holes, and then caulked, the timber is very durable.

In fine, good oak may be known by its appearance and gravity; it should be at the heart of the tree, of a pale yellow, gradually decreasing in brightness until it approaches the alburnum, or white wood: its pores should be small, and its fibres close. Oak of excellent quality, when dry, is in point of weight to that which is of a bad texture, as five is to seven, and its strength nearly in the same ratio.

Authors who have written on the age of trees, with regard to the quality of the timber, have differed in opinion as to the proper

period for felling them; some have considered that those which have stood eighty years, are preferable, others give them 100 *, and some have stated that oaks will thrive for more than 200 years. No general rule, however, can be laid down, for this purpose. While the trees have a thriving healthy look, without any appearance of decay in their top branches, they should be suffered to remain; as the timber not only improves in quality, but increases considerably in quantity, as each year a circle is formed over a still larger one in circumference, to the great benefit of the grower, and by the nourishment afforded through the vessels in the body of the tree, all the annual circles become more distended. But as soon as the trees begin to decline in vigour, which may be known by the decay of their upper branches, or becoming what is termed stag-headed, they should be felled, as it is a proof that they are on the decline, and if suffered to remain, the heart at the root will first become rotten, and then the whole tree will be gradually affected.

In point of density †, and consequently of strength, in thriving trees the heaviest and strongest wood is in the centre nearest the roots, which gradually decreases to the outer surface; but in those which have been for some time on the decline, the contrary is the fact; for the best and strongest wood is near to the alburnum, and the weakest at the heart. It may truly

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* Pliny, lib. xvi., cap. xxxix. To have good timber, the trees should be cut down that are of a middle age, for neither young poles nor old runts, are fit for durable building.

† Pliny, lib. xvi., cap. xxxviii. That part which is next the root, is far more weighty, settleth faster down, and sinketh.

be said, that in the same tree there are no two parts similar in weight, strength, or age, the heart being older, and as has been observed, stronger and heavier than the outer circles, and the butt than the top; under the before-mentioned limitations of age and condition.

CHAPTER II.

OPINIONS AND PRACTICES WITH RESPECT TO THE PROPER SEASON FOR FELLING OF TIMBER.

HAVING in the preceding chapter treated, of some of the qualities of oak timber, it now becomes necessary to advert, to what has been considered of much importance, the best season for felling it. The winter has been generally considered the proper time for the purpose; although this is a notion almost universal, yet it has not been without opponents. Among the ancients and moderns, whose opinions may be quoted as authority, Hesiod, Theophrastus, Pliny and Columella recommended the winter, Cato the end of summer, and Vitruvius the autumn;—as the proper period for felling trees. Plott, Evelyn, Du Hamel, Buffon, Hunter, and Knight, are advocates for winter felling; and it was an invariable practice in this country, to fell oak at that period, until the first year of the reign of James I. (1603,) when, for the encouragement of tanning, the practice was forbidden under the penalty of the forfeiture of the trees, or double their value in money, except for that timber which was required for the ships, mills, and houses belonging to the King. It has been supposed by some,

that these exceptions were granted in consequence of the superior quality of the timber felled in winter, but it is to be apprehended that they arose from other causes. When oak bark was used extensively for tanning of leather *, it became a valuable article, and of course if the price overbalanced other advantages, the growers of timber would fell it at such a period as would pay them the greatest sum; when this then was the case, no act of parliament was required to compel persons to cut down their timber in the spring; indeed, the act specified that it was to be felled in that season, "when the bark is worth two shillings the cart-load, over and above the charge of barking and felling;" but it is to be apprehended that the act was necessary, as the advantages of cutting it down and carrying it at a time when the labourers, oxen and horses belonging to farmers were unemployed, and the roads which at other times were almost impassable, became hard by frost; were inducements for felling in winter, which more than counter-balanced the advantages gained by the price of bark; and the fear, that if the act passed, no timber would be cut down, compelled the exceptions and the notice given of them in the public gazette of 11th December, 1603. But as the price of bark rose, and

* In order to render oak bark less valuable, and thus lessen the inducement to fell timber in the spring; it has been many times recommended to try experiments to extract the tan from the chips and sawdust, which arise in the conversion of the timber. Mr. Cleverly, a ship-builder at Northfleet, made an effort to accomplish this about twenty-five years since, but found that the tan was produced from bark at a cheaper rate. This result, however, may have arisen from the imperfection of the modes employed for the extraction.

the inducement to winter felling diminished, and while the prejudice in favour of it remained, the Navy-board were compelled to offer a bounty of *5l.*, then *6l.*, and finally *7l. 5s. per cent* for timber cut in the bark at that season.

Dr. Plott in his history of Staffordshire, published about the year 1686, recommended, in order to save the bark, and yet have winter-felled timber, that the trees should be stripped, or as he expressed it, "flayed in the spring," and felled in the succeeding winter, and stated that it was the practice in that county. He was prevailed upon by Mr. Pepys, then secretary to the Admiralty, to write a memoir thereon, which was entitled "*A Discourse on the most reasonable Time for felling Timber.*' In consequence of which, the King, (James II.), ordered that 150 trees should be stripped in the spring of the year in Bushy-park, and felled the succeeding winter; but as there is no record of the experiment, it is presumed that it was not carried into effect on account of the abdication of that monarch.

Dr. Plott and Mr. Pepys inferred, that the Royal Sovereign, a very durable ship, had been built of trees which had been stripped, as the practice was said to prevail in some parts of the north of England, whence they stated the timber for constructing her was brought; but there is no proof whatever, that such was the case with the timber of which she was built.

Evelyn, in his *Silva**, adverts to the practice of stripping trees in the spring, for the purpose of saving the bark. Sutherland,

* The first edition of this work was published in the year 1664.

in a work entitled "*Ship-building unveiled*," states, that the trees should be barked two or three years before they are felled, which is followed by a recommendation from M. M. de Buffon, and Du Hamel, that they should remain three * years excorticated before they were felled, by which the alburnum was said to become as hard as the heart; the former gentleman in the year 1738, published a paper thereon in the "*Memoires de l'Academie.*" The Dutch, about the year 1770, stripped their trees standing, since which time many persons have recommended the practice, and it has been done in most cases in his Majesty's royal forests since the year 1814.

The common opinion with respect to winter-felled timber is, that it contains less of the natural juices of the trees, than that cut down in the spring†; but that this is not the fact, has been proved by a variety of experiments; the same number of pieces, each containing the same quantity of timber, cut from similar situations in trees of the like age and growth, a moiety felled in winter, and the remainder in spring, were weighed, when each fall took place; the former was considerably the heaviest, but lost more in drying, so that when they were seasoned, the gravity of the winter-felled specimens was but little more than those cut down in the spring. These results were to be expected. When the air‡ vessels in trees, (which form nearly

* This plan was practised in England in the early part of the eighteenth century, as mention is made thereof in official documents, bearing date 1727.

† Mr. Biggen found that the oak, cut in winter, contained 2.1 of tan, oak cut in spring 9.6, and that the gallic acid in the former is as 8., in the latter as 10.

‡ It is not intended here, to enter into a discussion of the long-disputed point,

one third of the whole bulk of the heart in oak) by collapsing in consequence of the absence of heat, enlarge the sap vessels, the juices naturally descend by gravity*, and the decreased effect of capillary attraction, become more compacted, and when the wood is felled, the watery particles go off in vapour, but the glutin remains and fixes the vessels, which are in closer contact in winter than at any other season of the year; but, as has been before observed, the difference in weight is not considerable. Winter-felled timber is less liable to split or twist in seasoning, than that felled at any other season, arising, perhaps, from the evaporation being more gradual during the winter and spring months, or from the circumstance of the timber containing a greater quantity of glutinous matter.

It has been asserted that if the trees be felled in winter with the bark on them, the vivifying heat of the spring of the year will then cause a motion in the juices, and that the bark can be easily separated: that this is not the case, has been proved by recent experiments; some trees were felled in winter, with their bark on, in his Majesty's forests; and it was found in the spring that it would not rend, and when cleft from the trees, it might

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whether trees have vessels *(tracheæ)* to convey air to the several parts of their trunks, or to act as the lungs do in animals; or whether these vessels do, or do not contain liquid sap during some months of the year; but to conjecture whether the vessels in question, when nature does not employ them for the latter purpose, may not be the means of the rising and falling of the sap.

* Dr. Hales has incontestably proved, that there is no circulation in the juices of plants, that they ascend and descend in the same tubes, and fall in the night to rise in the day, by the influence of the rays of the sun.

be said to contain but little, if any, of the properties which make it valuable in tanning.

Trees, which have been stripped, are vigorous in throwing out leaves and in bearing fruit during the first year after the operation has taken place; in the second, the vegetation is feeble; and during the third, if in the spring, leaves appear, they generally die before the autumn. As the cold weather affects the stripped trees more than those in their bark, the decidence of their leaves takes place in each year at an earlier period, than in those which have not been barked.

Much importance having been attached to the use of winter-felled timber, and to the excortication of trees, it will be right to examine the grounds upon which the opinion is founded, by a consideration of the experiments. A late writer on the dry-rot is so sanguine in his recommendation, that it should seem, if our ships were constructed of excorticated timber, their duration would be extended to an indefinite time, and that we should have no more to lament the decay of the Navy, or of particular ships; it is with him a complete panacea; this, however, being hypothetical, is to be received as all hypotheses are, with much caution. The instances given by him, as well as by many others, are the Royal Sovereign, Royal William, Montague, Achilles, and Hawke; with respect to the first named ship, as has been observed, it was but conjectural, and with regard to the Royal William, the first notion that she was constructed of such timber, was in the year 1791, by the commissioners for land revenue; but there is no authority for the opinion, that she

was built with winter-felled timber; on the contrary, there is every reason to believe, that this ship was constructed of oak that was not selected, and that her durability arose from lying thirty-eight years in ordinary. That the practice of stripping trees, or indeed felling of timber in winter, was not common in the neighbourhood of Portsmouth, or practised in the New Forest at the time the Royal William was building, which was between the years 1716 and 1719, is proved by the following letter from Sir Jacob Acworth *, then Surveyor of the Navy, to Sir Isaac Townsend, commissioner of Portsmouth-yard, which, as it is considered, that it puts the matter at rest, is inserted at length:

Navy-Office, April 24th, 1718.

"Sir—Mr. Paramour has returned from Yorkshire, and given the Board an account of the timber affairs in that county; is ordered to return to Portsmouth, and with your leave, will acquaint you, that unless the price be advanced, we can have no great expectation of timber from those parts; however, as Paramour by his journey has perfectly acquainted himself with the peeling or barking timber standing, I hope by your assistance, that practice, which is very much used in some parts of Yorkshire, may be introduced into the timber counties whence the Navy is supplied; and when once the peelers are acquainted with it, and will do it, as they do it in Yorkshire at the same rate as if the timber were lying, the merchants will have the advantage of saving all their bark without extra charge, as well as the opportunity of felling timber at a season, when workmen are to be hired at cheap rates and carrying it to the yards all the spring as well as summer season; and by this means, in time his Majesty may have winter-felled timber on as easy terms from places where bark is dear as where it is cheap and of little value; and the receipt of timber at the yards as large in the spring of the year (as soon as ever the roads are fit for carting) as any part of the summer, which must be some advantage; and therefore to forward this affair, I must

* Sir J. Acworth was Surveyor of the Navy from the year 1715 to 1748.

beg you will endeavour to prevail with the merchants in your parts, to make a small beginning before this season is over, peel some of their timber, and let it stand till winter, which from your promise of making them a small addition to the price of summer-felled timber, I hope they will consent to, and in time they, as well as his Majesty's service, have considerable advantages from it; for though the timber peeled before 'tis felled, may not be altogether so good as timber felled in the winter with the bark on, I am persuaded it must be infinitely better than timber of the same kind felled in the summer, which has prevailed with me to give you the trouble of this long scrawl."

I am, &c. &c.,

JACOB ACWORTH."

Had then the Royal William been built of timber that had been peeled in the King's forest, or on private estates in the neighbourhood of Portsmouth, it would have been unnecessary for the Navy-board to have directed the attention of Mr. Paramour to the subject while he was in Yorkshire, in order to introduce it into Hampshire; or if it were then the practice to use timber felled in its bark in winter, which Sir Jacob Acworth preferred, would he have induced Sir Isaac Townsend to endeavour to introduce the practice of peeling it in Hampshire and the adjoining counties, at a time when that, which he considered better, could be readily obtained?

In the year 1774, there was a sufficient quantity of timber in Chatham-yard, which had been felled in its bark in winter, to build a ship of the line; this had been accumulating for some years, and in January 1775, the keel of the Montagu, of seventy-four guns was laid, and she was launched in August 1779; the ship was then transported to Portsmouth, to be laid up in ordinary; she received a small repair in 1782, and another small repair in 1790, and did not go into actual service until

May 1793, she again had a small repair in 1795, and was laid up, requiring a large repair, in 1801 ; the time that the timber lay in the yard before it was brought into use, and the long period that the ship remained in ordinary, no doubt materially tended to her durability. The Montague was taken to pieces at Chatham, in September 1818. The beams of a ship are always found to be most subject to decay, and it is to be noticed that no part of the beams of the Montague were fit to be again put into the ship when she received a large repair.

The Hawk sloop now comes under consideration ; she was launched from Deptford yard in 1793, having been constructed on one side with timber felled in the spring, and the other, with that which had been barked for three years, (according to the system of M. M. du Hamel and Buffon,) and felled in winter, the timber in both cases being the produce of the same estate ; when this ship was taken to pieces in 1803, no material difference could, it was then said, be discovered in the timber, as she was altogether in a very bad state ; but by a careful inspection of the drawings which were taken of the defective timbers, it appears, that those felled in winter were in the worse condition. The Fisgard of 46 guns, built in the year 1819 at Pembroke, is constructed on the starboard side, (with the exception of the plank under the line of fluitation,) together with one half of the beams, with timber stripped in the spring of 1814, and felled before the rising of the sap, in 1815, the larboard side with timber felled in its bark after the sap had risen in the spring of 1815.

In giving these statements, (which are the only accurate ones published,) it is not intended to imply that winter-felled timber is in no way superior to that cut down in the spring; its greater density would sufficiently prove the contrary; but to correct the notion which mere theorists and speculators have advanced, that if ships were built of this timber, they would last for an indefinite period, without being subject to rot of any kind. This is neither according to analogy nor confirmed by experience. Elm and beech timber in this country, and the oak from Canada, are always felled in winter, the latter is also water-soaken in its passage down the river St. Lawrence, but these woods are more subject to the different kinds of rot, than any other species of timber *.

The French, by the several *ordonnances* for the regulation of their forests, have directed the cutting down of timber in the winter months for naval purposes, and with the exception of the ships built at Toulon, they are decidedly inferior in durability to British ships of war.

At all periods of our naval history, it will be found that the officers of government have given a preference to timber which had been felled in the winter; in the year 1687, the "Navy-board" recommended the practice, but they apprehended "that

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* Charnock in his *History of Marine Architecture,* states that "the Sovereign, a ship built after the accession of Henry the Eighth, was totally unfit for service in the thirteenth year of his reign. The Gabriel Royal, though launched after the Sovereign, was in a still worse condition." These ships must have been built of winter-felled timber, as no other was then in use.

it could not be carried to any extent on account of the value of the bark, except the government thought fit to order it to be done in the King's forests." Whenever parliamentary or other inquiries, have been instituted with respect to the state of the timber in this country and its preservation, these recommendations have been repeated, without, however, assigning any reasons, except the one which experiments have proved to be fallacious, that it contains less of juices than that felled at any other season of the year. The sap-wood of the excorticated winter-felled timber, kept in piles in his Majesty's yards, has rotted and been equally as subject to fungus as that on timber felled in the spring; and the officers state, that there is no apparent difference in the alburnum or in the heart itself, and that "the sap and heart were not drier, or in a more seasoned state, for the trees having been stripped."

Even assertions of M. de Buffon are always to be received with respect; and the experiments which he made in conjunction with M. du Hamel, decidedly proved, that the timber which had been excorticated for three years, possessed a greater degree of strength; and there appears to be no reason, with this evidence before us, to believe that the failure in the Hawk is to be attributed to the timber having stood three years after the bark was stripped, before it was felled. As much importance is attached to the state of the sap-wood, it is to be lamented that there is no account from the officers of Deptford-yard, as to the hardness of the alburnum, on the timber converted for the Hawk. Some ship-builders of Hull purchased,

in the year 1810, a considerable quantity of timber, then growing in Finingly-park, Nottinghamshire; the proprietor allowed them three years for its removal; in order to make an early return of part of the purchase money, the timber was stripped of its bark, but the trees were felled and removed as they were required; in those, however, which had stood three years, it was observed, that the timber was far better, and that the sap-wood, having approached to nearly the consistency of the heart, did not perish by exposure to the weather, as the alburnum usually does *.

The sap-wood in trees, from eighty to one hundred years growth, forms nearly one-seventh of the whole quantity of timber in their stems; it therefore becomes desirable, in order to prove whether this can be brought into use, that the plan first practised in this country, and subsequently recommended by M. de Buffon, should be again tried; it is, however, right to remark, that after trees are deprived of their bark, they never increase in size. The additional expense of stripping timber standing, is 5*s.* per load, rough contents, or about 4*l. per cent.* on its present value. About Naples, and in other parts of Italy, oaks have been felled in the middle of summer, and are said to have been very durable. The usual time of felling timber in England, is from the end of April, till the beginning of June, but the period depends upon what is called the running

* The timber was purchased by Messrs. Barkworth and Hawkes of Hull, and the author has the authority of the latter gentleman for this account.

of the sap *, which is earlier or later, according to the state of the temperature of the air.

Vitruvius recommended that a cleft quite through the alburnum, should be made in the trees near their roots; by which means the sap *(succus communis)* will exude, and according to his account, "the oak will acquire thereby a sort of eternity in its duration." Pliny repeated this recommendation. Several trees were so treated in his Majesty's forests in the spring, while they were in leaf; the result was, that where the sap-wood was completely cut through the vegetation ceased, and the leaves immediately withered: but in those cases where the division was not complete, the trees still continued to vegetate in a direct line in that part where the communication was not cut off; sufficient time has not elapsed to ascertain the comparative durability of this timber.

The ancients supposed, that the moon and other planets governed the animal and vegetable kingdoms; the proper time for felling of trees with them, was usually considered to be in the wane of the moon. Hesiod states, that "it is deemed improper to fell any timber for ship-building, except on the 17th day of the moon's age, because she being then in the wane, the sap or internal moisture which is the grand cause of early decay, would be sunk, or considerably lessened." Cato con-

* It is proper to remark, that the sap in oak trees runs at two periods of the year; the second usually takes place in July, but it is not then so abundant, the bark at this time being considered only of half the value of that stripped in spring.

sidered the 4th day after the full to be the best time, and that the trees should be felled in the afternoon, when the wind is not southerly. Pliny recommended the wane of the moon from the 20th to the 30th day, when the wind Favonius (the south wind) blows. Vegetius from the 15th to the 30th day of the moon. Notwithstanding these recommendations, and although the decline of that planet has always been directed to be observed in France, in the *ordonnances* respecting the felling of timber, yet, there does not appear to be good grounds for the preference.

Upon a review of all the circumstances, these conclusions are to be drawn; that winter-felled timber is somewhat heavier, stronger, and less liable to rend or twist, than that felled at any other time of the year; but that wood of a good quality is durable at whatever season it may have been cut down *, provided it be well dried before it is brought into use; but if it be felled at any time of the year and worked into a building before the juices are evaporated by seasoning, and a free circulation of air then prevented, it will ferment, corrupt, and be subject to early decay.

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* Leuwenhoeck gives, as his opinion, that winter-felled timber is as full of juices as that felled in the spring, and that there is no difference between them, except in the bark, and outermost rings of wood.—*Philosophical Transactions, Vol.* 18, *page* 224.

CHAPTER III.

ON THE DIFFERENT MODES OF SEASONING TIMBER.

THERE is no object of greater importance to the civil and naval architect, than the proper desiccation, or, as it is usually termed, seasoning of timber: except this be done to a considerable degree, their work will be imperfect from the shrinking of the materials, and the wood will be subject to premature decay. During the periods of political repose, this subject has at all times engaged the attention of the government, and very many wholesome regulations have at those times been given, for stowing away timber, and protecting it while it remained in piles, whether in a rough, sided, or converted state; but the urgency of war generally rendered them nugatory, by compelling the officers of the dock-yards to use that which was unseasoned, and also by diverting the attention of those persons whose duty it was to superintend this important store, to what are then considered objects of greater moment.

Hence it is, that after wars of any continuance, complaints have always been made of the defective state of the fleet. The timber was stowed during the whole of the last century, (in

times of peace) on places, or as they are technically termed, births, which were paved with flat stones, lying at an angle of inclination, and having water-courses to carry off the rain. To prevent vegetation between the stones, they were strewed with cinders from the smiths' forges; the lower tiers were raised from the pavement, by resting upon skids or beams of dry timber, about twelve inches square; and to promote a free circulation of air, each tier was supported by similar pieces, but of less dimensions. These piles were protected from the weather by temporary roofs. Timber was converted for the ships ordered to be built, and laid apart according to the same arrangement; and as it seasons more rapidly, when cut to the moulds, than in a rough or sided state, after it had lain for some years under cover, it was brought into use considerably desiccated: one thing, however, was wanting, protection from the weather while the ships were being built. The timber in the Dock-yards is now stowed and housed according to this method; with the exception, that the lower tiers rest upon stone, or cast-iron supporters, instead of wood. Thick-stuff* and plank were placed in permanent buildings, fitted with racks, called seasoning sheds; for the want of ground space in most of the Dock-yards, these houses were either razed during the late wars, or converted to other purposes; but as those articles suffer great deterioration by exposure, it is to be hoped that the old method of preserving them will be again established.

* All plank of more than four inches in thickness is called thick-stuff.

As soon as timber is felled, seasoning may be said to commence; the logs should be placed on skids, if it can be done with convenience, to raise them from the mould or grass, for nothing injures the trees more, than being alternately dried by a partial exposure to the sun and air, and then moistened by exhalations from the earth.

Much has been said, as to the best mode of keeping the timber; some have been advocates for having it in a rough, others in a sided, and there are those who prefer a converted state. The former no doubt is preferable if it be exposed to the vicissitudes of the weather, and if there be a sufficient store to allow of its being kept from three to five years; the latter, however, are to be preferred, if it be preserved under cover, or if necessity oblige it to be used at an early period, as the seasoning will be more rapid. There are circumstances which make it politic to side timber on the spot where it grew; in situations where there are no canals, the land-carriage is very expensive, as much in some cases as 4*l.* or 5*l.* per load; thus, if it be in a rough state, enhancing the price of the valuable part of the timber, by the same sum being paid for carriage on the inferior part. The slabs, or those pieces taken off by the saw in siding the trees, are brought into use for posts, gates, paling, barn-floors and other country purposes; were not these wants supplied by such means, young thriving trees would be felled for those uses, and thereby increase the expenditure of that valuable and now scarce article, British oak.

Oak timber from the King's forests, is sent to the Dock-yards

roughly hewn; that purchased of individuals, generally in a sided* state. It was the practice at an early period of the seventeenth century, when large falls of trees took place in any part of the country, to send proper moulds to convert the timber on the spot where it grew, for the purpose of building particular ships, for

> "No want of timber, then was felt or fear'd
> "In Albion's happy isle————."

As population increased, and the demands both for the necessaries and luxuries of life became greater, the timber in forests belonging to individuals was cut down, and the land put into cultivation for the production of grain. The same motive induced the proprietors of estates to grub up the trees in the hedges; thus timber became scarce, was procured in small quantities, in different parts of the country, and this mode of conversion rendered impracticable.

The fall of timber each year, even in the King's forests, is not sufficient to carry into effect the conversion of it on the spot. As the trees vary in size, so are they applicable to different classes of ships. Besides which, the extensive scale of naval

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* The rule for siding of timber is "that it shall be so sided, that between the wanes at half the length of the piece, there be not less than the siding with one-eighth added thereto, and to be fairly sided from end to end parallel, to be measured for contents, as far as it holds at the top end on each side between the wanes two thirds of the siding of the piece, such pane to determine the length of the piece. The sided timber to be so hewn the moulding way at the several measuring places, that the two squares taken together, shall be equal to five-sixths of the diameter of the log when hewn at those places."

operations in this country, in building, repairing, and equipping ships, render it frequently necessary to appropriate (if they are found applicable,) timbers, laid apart for particular objects, to more pressing services; so that if the timber were in a converted state, great delay and inconvenience would be frequently experienced for the want of particular pieces.

In France in particular, and in other naval states on the Continent of Europe, where forests are extensive, and the governments claim a preemption of the timber, moulds are sent and the trees converted on the spot where they grew; hence a great saving in the price of carriage takes place. This practice now prevails in the United States of America.

The stowage of timber is a consideration of primary importance; it is an indisputable fact, that in the dock-yards where it was properly stacked, the ships constructed therein have been uniformly more lasting, than in those where equal care was not taken. Piles of timber should be taken down, and re-stacked once in every year, and those pieces that were at the top, placed at the bottom, and all have their sides reversed; defects arising from knots, or other circumstances, should be cut out, pieces put in, and afterwards caulked. Where logs of timber can be placed vertically, it should be done, as they will season better than if placed horizontally; this, although contrary to the opinion of Evelyn*, has been proved to be the case by many experiments.

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* *Silva*, book 3d. chap. 4th.

Although it does not appear to be practicable on the large scale on which the concerns of the Dock-yards are conducted, to have permanent buildings, with chimneys to carry off the vapour that will arise from the timber while drying, (similar to some which have been erected in France;) yet much has been, and more still may be done, to prevent the pieces coming in contact, and to protect them from the alternations of a scorching sun to separate the fibres, and a drenching rain to fill the spaces thus formed, with moisture; but care should be taken in all cases to hinder a violent rush of air, which would also cause the timber to split, by absorbing the moisture more rapidly than the fibres collapse.

High ground is to be preferred for stowing logs, as their seasoning will be retarded and quality injured by damp vapours, particularly the miasma, rising from marshy ground.

It has sometimes been the practice in this, as well as in other countries, to immerse timber in fresh or salt water; either with a view to prevent its splitting, to check the corruption of its juices, or as some have said, to facilitate the seasoning by dissolving the incipient timber.

The necessity of immersion may arise from different causes, in different situations; to prevent its rending in warm countries, as a protection from land worms, or to guard it from injury in places where the weather is very variable. The Venetians, probably from the heat of the climate, sunk their oak in salt water. Mr. Strange, for many years British consul at Venice, gave in evidence before the commissioners for land revenue in 1792,

" that he was told by some intelligent Venetian shipwrights, that great prejudice is derived from the custom that prevails there, of throwing the timber fresh cut into salt water, and letting it lie until wanted; afterwards it is dried and withered on the outside under sheds, while the inside being soaked with salt water, rots before it becomes dry, for the salt moisture not only rots the inside of the beams and timbers, but rusts and corrodes the iron bolts." In Sweden it was common for land worms to injure the timber; Linnæus was consulted, and he recommended its being sunk in salt water, during the period that those animals deposited their eggs; this prevented the mischief, and it was found that the worms did not afterwards do much injury to the wood that had been immersed, when it remained on the land. The Dutch sink their timber in fresh water, and consider by this process, that its durability is increased; perhaps, in a marshy country like Holland, with oak of open grain, and where they are subject to much rain, there could be no better mode of preserving it; the time they consider that it should be sunk, is, for timber six months for every inch in thickness, and in order to do it effectually, it is no uncommon thing for them to cut large timbers through the middle, and to work them in two pieces. Plank for ships' bottoms usually lies, in Holland, nine months in water. At some ports in America, it is the practice to soak timber in fresh, and at others, in salt water. The French at Brest*, placed the timber in fresh water,

* On a imaginé différens moyens de conserver les bois, mais aujourd'hui on s'en

which they preferred, and at St. Maloes it was put into damp sand. At the latter part of the seventeenth, and at many periods in the eighteenth, century, immersion of timber, at some places in fresh, and at others in salt water, has been practised in this country by the directions of the Navy-board at large, or of the Surveyors of the Navy; it gradually grew into disuse, but why that mode was altogether discontinued does not appear; it has, however, been renewed within the last three years, by putting the sided and converted timber and plank cut from English oak, for at least three months, into fresh water at Deptford and Woolwich, and into salt water, at all the other dock-yards.

Fresh water penetrates the wood more readily than salt, for after it may be considered to be saturated with the former, it will take up a considerable quantity of the latter. If saturation of the timber, or in some degree maceration of the fibres, be aimed at by immersion, fresh water is to be preferred, for the salt will, in some degree, fix the sap. A running stream is also preferable to a stagnant pond.

The notion of completely saturating large pieces of timber to their centre is fallacious, for very small cubes, (those of an inch for instance,) when sunk, even in fresh water, have been found to increase in weight for many months. The proper period for putting timber into the water is the spring of the year, that the

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tient à les garder sous l'eau; et dans le port de Brest, ils sont empilés dans la rivière de Pinfeld, sous leurs différentes désignations, marquées sur une étiquette en planche, clouée au bout d'une perche: au moins cela doit-il être ainsi. Les grands mouvemens actuels troublent un peu cet arrangement (1782.) *Encyclopédie Méthodique*, part Marine, article Bois.

temperature of the fluid may gradually increase with the warmth of summer; for some time it will appear to throw out small air bubbles, and after lying a few days becomes covered with a sort of slime, arising probably from the solution of some of the particles of the wood.

Water-soaking deprives timber of a considerable proportion of its strength; wood of an excellent quality after it has been laid in water for some time, assimilates in strength, and has the outward appearance of that which has not been immersed, but which was originally of an inferior texture.

Among the authors who have written on timber, there are numerous advocates for putting it for some time into water. Vitruvius recommended that it should be immersed for thirty days; Evelyn, in his *Silva*, says "hence by *floating* comes the Bohemian plank, Polish and other northern timber, to be of such excellent use for some parts of shipping," and he, Dr. Hales and Ellis assert, that beech and elm are much improved by being put into water, particularly salt, that it gives them an admirable seasoning to be used for barn-floors and other purposes. And Mr. Nicholls*, whose opinion with respect to timber was held in high esteem in this country, recommended that it should be sunk in salt water.

Immersion† has also been recommended for the speedy

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* See the *Report of Commissioners for Land Revenue in* 1791.

† Oak takes up more water by immersion than any other timber, and increases in weight thereby according to its quality, size, and the degree of desiccation it had undergone, or whether placed in salt or fresh water; the increase of weight may,

seasoning of oak timber, and much importance attached to keeping the pieces inverted, or, in other words, putting them in a contrary direction to that in which they grew; under the supposition that there are valves in the tubes through which the sap passes, that open in living trees by the force that it exerts in ascending, but close to prevent its descent. In order to prove the efficacy of this plan, six pieces of rough and six of sided timber were put into the mast-pond at Deptford, and twelve pieces of rough, and twelve of sided timber, and six pieces of thick-stuff, were placed in the mast-pond at Woolwich; the like quantity of timber and thick-stuff was kept at both ports out of water, protected from the weather, a moiety of each having their butts downward, the remainder their tops; the pieces were selected from timber felled at the same period, out of the same forest, and were, as nearly as they could be got, of the same texture and weight. And in order also to prove what difference takes place in the seasoning of timber, subject to lie wet and dry twice in twenty-four hours, six pieces of sided timber were placed in the outer mast-pond at Woolwich, into which the tide flows, but this basin is dry a considerable time before low-water. As these experiments are, it is believed, novel, a full account thereof is given.

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however, be estimated in dry wood, at about one-sixth, and in that which is very green at not more than one-thirtieth.

AN ACCOUNT of some Pieces of Timber and Thick-stuff, which remained under Water for Six Months, in the Mast-Ponds in Deptford and Woolwich Dock Yards; and also of some which were kept out of the Water under Cover, in order to prove whether they lost more in Weight by having their Tops or Buts placed Downward, and whether Immersion is, or is not, an expeditious Mode of Seasoning Timber.

AT DEPTFORD.

Description of the Timber.	Weight, when placed under water 12th April 1817.		Weight, after having been six months in the water.		Weight, 12th April, 1818.		Weight, 23d June, 1819.		Weight, 21st December, 1819	
IN WATER.	But down	Top down	But down	Top down	But down	Top down	But down	Top down	But down	Top down
	cwt. qrs. lbs.	cwt. qrs. lbs.	cwt. qrs. lbs.	cwt. qrs. lbs.	cwt. qrs. lbs.	cwt. qrs. lbs.	cwt. qrs. lbs.	cwt. qrs. lbs	cwt. qrs. lbs	cwt. qrs. lbs.
Rough oak timber - - -	8 0 25	8 0 0	9 2 14	9 0 0	8 1 0	7 3 7	7 1 22	7 0 21	7 1 5	7 0 5
,, - - - -	10 1 21	10 3 7	11 3 14	12 1 14	10 1 22	10 3 0	9 1 23	9 3 5	9 0 27	9 2 13
,, - - - -	10 1 21	9 0 25	11 2 7	11 1 0	10 2 0	9 1 14	9 2 11	8 0 21	9 1 20	7 3 27
	29 0 11	28 0 4	33 0 7	32 2 14	29 0 22	27 3 21	26 2 0	25 0 19	25 3 24	24 2 17
Sided oak timber - - -	7 1 7	7 0 25	7 2 21	7 3 14	7 0 10	7 0 0	6 1 16	6 1 0	6 0 21	6 0 7
,, - - - -	7 1 0	8 1 7	7 3 21	9 1 21	7 0 7	8 1 21	6 1 6	7 2 4	6 0 14	7 1 7
,, - - - -	8 2 0	9 1 0	9 1 14	9 2 14	8 1 0	8 3 21	7 1 7	7 3 14	7 0 10	7 2 12
	23 0 7	24 3 4	25 0 0	26 3 21	22 1 17	24 1 14	20 0 1	21 2 18	19 1 17	20 3 26
OUT OF WATER UNDER COVER.										
Rough oak - - - - -	7 0 14	8 1 0			6 3 14	8 0 0	6 0 18	7 1 17	6 0 10	7 1 9
,, - - - -	9 3 14	10 1 7			9 1 7	9 3 7	8 2 24	9 0 24	8 2 11	9 0 15
,, - - - -	8 2 7	7 0 0			8 0 8	6 2 10	7 2 2	6 0 25	7 1 22	6 0 15
	25 2 7	25 2 7			24 1 1	24 1 17	22 1 16	22 3 10	22 0 15	22 2 11
Sided oak - - - - -	8 0 0	7 2 14			7 1 7	7 0 0	6 2 27	6 1 22	6 2 15	6 1 11
,, - - - -	7 1 14	7 2 0			6 3 14	6 3 14	6 1 18	6 1 12	6 1 7	6 1 0
,, - - - -	8 3 0	9 0 14			7 3 21	8 1 14	7 1 7	7 2 18	7 0 18	7 2 2
	24 0 14	24 1 0			22 0 14	22 1 0	20 1 24	20 1 24	20 0 12	20 0 13

AT WOOLWICH.

Description of Timber.	Weight, when placed under water in December 1816.		Weight, in December 1817, after having been six months in, and six months out, of water.		Weight, July 1819.	
UNDER WATER.	But down	Top down	But down	Top down	But down	Top down
	cwt. qrs. lbs.	cwt. qrs. lbs.	cwt. qrs. lbs.	cwt. qrs. lbs.	cwt. qrs. lbs.	cwt. qrs. lbs.
Rough oak timber - -	12 3 21	13 0 7	12 0 6	12 2 21	10 0 17	11 3 3
,, - - - - -	12 1 0	14 3 21	11 3 0	14 0 18	10 3 22	13 0 18
,, - - - - -	13 1 7	11 2 14	12 2 21	10 3 14	11 3 5	10 0 13
,, - - - - -	17 0 0	12 3 7	16 0 20	12 0 21	14 3 25	11 0 23
,, - - - - -	14 2 7	13 3 7	13 3 10	13 0 11	13 0 6	12 0 10
,, - - - - -	14 0 7	15 0 7	13 1 16	14 2 7	12 1 21	13 1 25
	84 0 14	81 1 7	79 3 17	77 2 8	73 1 12	71 3 8
Sided oak timber - -	13 1 7	13 2 0	12 2 16	12 3 14	11 2 15	11 3 21
,, - - - - -	11 3 14	16 0 0	11 1 9	15 0 3	10 1 23	13 3 10
,, - - - - -	15 0 14	13 1 0	13 3 26	12 0 14	13 0 10	11 1 17
,, - - - - -	13 2 7	14 2 7	12 1 17	13 1 9	11 1 7	12 0 11
,, - - - - -	11 1 7	12 0 7	10 1 5	10 3 26	9 1 20	9 3 22
,, - - - - -	12 1 0	13 1 12	11 0 10	12 0 21	10 1 2	11 0 23
	77 1 21	82 2 26	71 2 27	76 2 3	66 0 21	70 1 20
Thick-stuff, 6 inches -	5 3 0	6 3 0	5 0 16	6 0 11	4 2 0	5 1 14
,, - - - - -	6 0 7	5 0 21	5 2 9	5 0 9½	4 3 5	4 1 22
,, - - - - -	6 0 0	6 1 0	5 1 18½	6 0 0	4 3 5	5 0 24
	17 3 7	18 0 21	16 0 15½	17 0 20½	14 0 10	15 0 4
OUT OF WATER UNDER COVER.						
Rough oak timber - -	12 1 14	11 3 7	10 3 2	10 1 10	10 0 10	9 3 1
,, - - - - -	11 3 7	14 3 0	10 2 18	12 3 7	9 3 21	12 0 3
,, - - - - -	13 1 7	11 2 7	11 2 23	9 3 14	10 3 26	9 0 27
,, - - - - -	17 1 0	11 3 7	15 3 14	10 2 9	15 0 5	9 3 20
,, - - - - -	14 2 21	13 2 21	12 2 13	11 2 10	11 3 5	10 2 25
,, - - - - -	14 0 7	16 2 0	12 0 8	14 3 6	11 1 10	13 3 10
	83 2 0	80 0 14	73 2 22	70 0 0	69 0 21	65 2 2
Sided oak timber - -	11 3 7	11 3 7	10 2 18	10 3 21	10 0 23	10 1 7
,, - - - - -	11 1 7	14 3 0	10 0 23	13 0 21	9 2 14	12 1 20
,, - - - - -	13 2 0	11 1 3½	12 1 11	10 0 16	Missing.	9 2 5
,, - - - - -	12 3 3½	13 1 21	11 1 2	12 0 0	Ditto.	11 0 15
,, - - - - -	11 1 7	10 0 21	10 1 3	9 0 19	9 3 12	8 2 10
,, - - - - -	10 2 21	11 2 3½	9 3 12	10 3 4	9 0 24	10 0 12
	71 1 17½	73 0 0	64 2 13	66 0 25	38 3 17	62 0 13
The following were placed in the Outer-Mast Basin and alternately wet and dry.						
Sided oak timber - -	12 3 7	11 3 7	11 3 21	10 3 19	11 0 2	10 0 5
,, - - - - -	12 1 0	12 3 0	11 1 13	11 2 24	10 1 14	10 3 14
,, - - - - -	11 2 0	15 2 7	10 3 0	14 2 14	9 3 20	13 2 25
	36 2 7	40 0 14	34 0 6	37 1 1	31 1 8	34 2 16
Thick-stuff, 6 inches -	7 0 0	5 2 3½	5 3 23	4 3 7½	5 2 1	4 1 9
,, - - - - -	6 0 3	5 2 3½	5 0 20½	4 3 10½	4 3 1	4 1 22
,, - - - - -	6 0 0	5 1 7	5 1 15	4 2 15	5 0 0	4 1 0
	19 0 3	16 1 14	16 2 2½	14 1 5	15 1 2	13 0 3

The results of these experiments are,—that timber is better seasoned when kept for two years and a half under cover, than when placed for six months in water, and then for two years in the air, protected from the rain and sun ; that it loses more in seasoning, by having been, during the six months of immersion, alternately wet and dry, than the whole time under water ; and that the loss in moisture is greater in all cases in a given time, when the buts are placed downwards.

The degree of seasoning, in point of time, that wood requires before it is used, depends upon its density, the situation and manner in which it has been kept, and also whether it be in a rough, sided, or converted state. As a general principle, however, no timber should be brought into use in this country, until it has been felled at least three years ; hence the desire of government to have in their naval arsenals a stock equal to three years' consumption. Independently of the advantages of using seasoned timber, it affords the officers a greater scope in their selection, and enables them to be more economical in their conversions ; for there cannot be a greater mistake than to believe, on account of the deterioration that some of the pieces will necessarily undergo by being kept, or the consideration of the interest of the capital laid out, that it is economy to suffer the store of oak timber and Dantzic (or, as it is sometimes called, North-country) oak plank to decrease below three years' consumption ; whatever sum of money may be laid out, it is expended to great advantage, for should it suffer deterioration, by shewing as it seasons radical defects, it is surely better to dis-

cover them in this state than to have the timber rot, shortly after it is worked in ships.

Wood cannot be said to be seasoned unless it is brought to that state of dryness that it acts as an hygrometer, by weighing more or less, according to the damp or dry state of the atmosphere; good oak timber felled in summer, will lose about one-third of its weight, if placed under cover; that felled in winter rather more, before it is brought to this state. There are two pieces of timber, (cubes of one foot each,) preserved in a warm room in Somerset-house, which were cut from trees three feet from their buts, that grew in the New Forest in Hampshire: the timber was felled on the 15th Nov. 1791; the one was cut down in its bark, and the other had been stripped the preceding spring; the following are the results:

	Tree in the Bark.		Stripped Tree.	
Weight when felled.....	62*lbs.*	0 *oz.*	68*lbs.*	0 *oz.*
——— 30 Jan. 1792....	49	0	53	8
——— 20 Sept. 1796....	37	0	41	10
——— 29 Jan. 1799....	37	0	41	8
——— — Dec. 1803....	36	8	41	1

The pieces after this time continued to weigh a little more or a little less, according to the state of the atmosphere.

It is proper to remark, that the tree which had been excorticated was of a much closer texture, and by a comparison of the annual circles, of much slower growth than the other. Two pieces of oak, (each a cubic foot,) were cut from the buts of trees which had grown in Sussex; the timber was of a very close texture; the one was then placed in a room in which a fire was

kept occasionally, the other exposed to the vicissitudes of the weather; the following are the results:

	Kept in a Room.	Exposed to the Weather.
Weighed when cut, 1 April, 1801.	70*lbs.* 7½*oz.*	72*lbs.* 4½*oz.*
1 July, 1801, ...	56 4	61 10
1 April, 1802, ...	48 10	59 0
1 July, 1803, ...	45 0	55 8½

These experiments were not continued.

Dry oak, according to Count Rumford, contains one-fourth of its weight of water, very old oak at least one-sixth. The ancients used smoke* and artificial heat to season wood, and the latter has been recommended many times for this purpose, within a few years. Mr. Joy, a carpenter in the British Navy, proposed, in the year 1727, that ovens should be erected in the dock-yards, to season the timber, but which was not carried into effect, as it was considered that great heat would cause the wood to split. In this country, and in our own time, a philosopher† of much celebrity has stated "that it is highly probable that the mere circumstance of timber having been exposed to a high degree of heat, may be sufficient to destroy all tendency in the timber itself to originate dry-rot." Fourcroy, too, in his "*General System of Chemical Knowledge*," has recommended the drying of timber in ovens to increase its durability‡. If,

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* Et suspensa focis, explorat robura fumus.

VIRGIL., *Georg.*, *Lib.* 1,; also PLINY, *Lib.* 23. *Cap.* 1.

† Dr. Wollaston.

‡ M. Pallas, in his prize essay for the year 1779, proposed the following plan, in order to season wood expeditiously, that places should be formed in the forests, in the

however, it should be considered proper to use artificial heat, it must be regulated, for if carried a little higher than boiling water, (212° of Fahrenheit,) the hydrogen and oxygen combine and form water; the timber at first, will be considerably weakened, and if the heat be continued, will, at length, become carbonized. The oak, which has been dried by artificial means, attracts and imbibes moisture from the atmosphere; some very dry wood was put into an oven which was kept for some days at 100° of Fahrenheit, and its gravity was considerably diminished, but after having been exposed for some time (under cover,) to the influence of the air, it absorbed sufficient moisture to regain the weight which it had, before it was exposed to that degree of heat. It is right to remark that without a proper quantity of moisture, all timber loses its tenacity, may easily be separated fibre from fibre, and at length when all moisture is extracted, it becomes friable between the fingers.

Oak seasons in a shorter or longer time, and in a more or less complete manner, in the proportion that the surfaces exposed bear to the solid contents of the several pieces; but a much

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most exposed situations to the sun's rays, lying at angles of inclination, which were to be paved with flints or rough stones: these, and the timber placed on them, were to be covered, for about two inches above the surface, with sand or fine gravel, in which it was to lie until properly dried. If the timber were required in a short time, the temperature of the sand bath was to be raised by stoves, placed under the pavement. The author states that he has seasoned timber of large dimensions expeditiously by this method, and without its having rents or cracks; and that the sap-wood of trees, that had been excorticated in the spring and felled in winter, was changed into heart, when they had undergone this process. See the First Part of the *Acta Acad. Scient. Petrop* for 1779.

greater evaporation takes place from the longitudinal than the lateral tubes, which are usually termed the silver grain.

It appears upon a due examination of all circumstances, that the best mode of seasoning timber, and to prevent its being injured during that process, is to keep it in air, neither very dry, nor very moist; and to protect it from the sun and rain, by a roof raised sufficiently high over it, so as to prevent, by this, as well as other means, a rapid rush of air *.

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* A recent experiment has proved very forcibly the correctness of this opinion. In the middle of the year 1814, a stack of timber was formed in Deptford yard, according to a plan recommended by Mr. Sowerby, and this was carried on under his inspection. The method of forming the pile was as follows,—there were sixteen piers formed of brick, with stone caps placed in four rows, upon pavement lying at an angle of inclination, to carry off the rain-water; these were three feet six inches in height, and ten feet asunder: on each pier two pigs of iron ballast were laid, which being 6 inches square (and 2 feet ten inches long,) made the height of the supports four feet. On these, pieces of sided oak timber were laid as skids, and other pieces crossed them with a considerable separation between each, and by this manner of stowage the pile was raised several tiers. The timber remained in this state until June 1820, a period of five years, when it was unstacked for use; although it was a little rent, it had externally a fine and sound appearance, but the whole was found upon conversion, to be more or less internally decayed, except in those parts where the timber had crossed; the heart of the several pieces resembled the soft spongy sap-wood, or as it is sometimes called touch-wood, but there was no appearance of fungus either externally or internally. There appears to be no doubt but the rapid draught of air, speedily closed the external vessels of the timber, which prevented the escape of the juices, and these being in sufficient quantity to bring about fermentation, decomposed the wood.

CHAPTER III.

ON THE EMPLOYMENT OF CHEMICAL MEANS, TO PROMOTE THE DURABILITY OF TIMBER.

THE slow growth of trees, and the rapid decay of timber *, when improperly treated, or placed in unfavourable situations, have induced many persons of talent and experience to propose, and in some cases to carry into effect, means, which they considered would tend to prevent the early dissolution of wood of different kinds.

The durability of box, teak, ebony, lignum-vitæ, and some other trees, has induced the examination of their component parts, and the consideration of the properties to which this effect may be attributed.

Timber which remains the longest under any circumstances without an apparent change, (such as teak †, lignum-vitæ, *&c.*,)

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* Corpora lente augescunt, cito extinguuntur.—TACITUS.

† *Tectona grandis*, (the teak tree,) or as it is sometimes called *quercus Indica*, (the Indian oak,) belongs to the class *pentandria*; it is found in most parts of the East Indies; great quantities are felled in the Pegu, and southern part of the Birman, empires: this tree, like the oak of Europe, is of a better or worse quality according to the soil on which it grows and its exposure to the sun and wind. It decreases in volume

generally abounds with oleaginous and resinous matter, which being insoluble in water, resist its effects and thus prevent decomposition. Almost all the substances that are known to possess antiseptic properties, and these sometimes, combined with others having septic ones, have been proposed and in many cases tried, with a view to render by art those kinds of woods indestructible, which experience has proved, when in their native state, to be prone to early decay. The consideration of the experiments which have been tried, and others which have been proposed, that carried with them some degree of plausibility, in order to prevent the decomposition, and increase the durability of timber, will be the subject of this chapter. The following are the chief ingredients which have been recommended, and some of them tried, to prevent the decomposition of timber and the growth of fungi.

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but in a small degree by seasoning, and afterwards suffers but a slight alteration by heat or cold, dry air or moisture; hence it is that teak ships are very strong, as the several pieces of which they are composed always retain their bulk and remain in contact; its strength compared with English oak, may be considered in the proportion of nine to seven. The ships belonging to the British navy, built at Bombay, are constructed of Teak, its durability is great, as there are several instances of vessels built of this timber, the frames of which are sound, after a service of one hundred years. Tar of an excellent quality is to be obtained from teak, and in such abundance that the chips arising from the conversion of the timber requisite for the construction of the ship, are sufficient to afford a plentiful supply, not only for the purposes required on the hull, but also for the rigging. A small quantity of teak tar has been imported into this country, and found to have the best effects in preserving cordage and adding to its strength. It is a common practice in India, to cut through the sap-wood of this tree, all round, at the root, and let it remain in this state twelve months before it is felled.

Sulphate of Copper,
——— Iron.
——— Zinc.
——— Lime.
——— Magnesia.
——— Barytes.
——— Alumine.
——— Soda.
Carbonate of Soda.
——— Potash.
——— Barytes.
Acid—Sulphuric
——— Vitriolic.
——— of Tar.
Salt—Neutral
—— Selenites.
Oil—Vegetable.
—— Animal.
—— Mineral (Coal)
Resins of different Kinds.
Muriate of Soda.
Quick-Lime.
Animal Glue.
——— Wax.
Sublimate, Corrosive.
Nitrate of Potash.
Marcasites, Mundic.
——— Barytes.
Peat-Moss.

From a want of chemical knowledge, some persons have recommended ingredients as preservatives, which, if applied, would have been decomposed by the tannin or by the gallic acid contained in the oak, and thus rendered, if not prejudicial, at least useless; while others, having lost sight of the fact, that in shipbuilding the metallic fastenings are most important, have recommended substances that would quickly corrode, and in time destroy those both of copper and of iron.

As the decay of timber frequently proceeds from its undergoing fermentation, and finally putrefaction, and as strong acids are known to arrest the putrefactive process, Mr. Reed, about the year 1740, proposed that it should lie steeped for some time in the acid of tar; but no steps appear to have been taken at that time to prove its efficacy. This proposition was renewed, in the year 1802, by Mr. Sanderson, who, as an additional pre-

caution, recommended that the timber should be afterwards boiled in the oil of vegetable tar; the experiments were then tried by placing some pieces of wood which had been so prepared, with the same number of others which had not, on the under side of the magazine beams of a ship; after five years had elapsed, the result was, that there was not any perceptible difference in the state of the several pieces, but the iron nails which attached to the beams those that had been prepared with the acid, were so quickly corroded, as to render it necessary to renew them twice during that period. Dr. Hales also, in the year 1756, proposed that tree-nails * should be soaked in the acid of tar to preserve them †.

The muriate of soda, (common salt used for culinary purposes) from its known antiputrescent properties, when applied in large quantities, has frequently engaged attention for the purpose of preventing the decay of timber. Mr. Jackson, a practical chemist, recommended in the year 1767, to put as much of this, "mixed with lime, copperas, alum, epsom-salts, and pearl-ashes, into sea-water, as it would hold in solution," to steep the timber therein, and in most cases to use the agency of heat. Holes were afterwards bored in the timbers, and the same ingredients

* Tree-nails are wooden cylindrical pegs, much used for connecting the plank, to the timbers of ships.

† M. Pallas, in 1779, proposed, as he said, to mineralize timber, in order to add to its durability; this was done by macerating, or steeping the wood in a solution of green vitriol, until it had penetrated deeply; the timber was then to be placed in lime-water to precipitate the vitriol.—See the *Acta Acad. Scient. Petrop.* Part I., for the year 1779.

put into them in a crude state, that if any moisture remained, they might be diffused in solution through the centre of the timbers; and if there was not sufficient moisture for that purpose, they were occasionally wetted with a strong solution of muriate of soda; when these were dissolved, some pulverized roach alum was put into the holes, and suffered to remain a week, or until dissipated; the holes were then plugged up.

Between the years 1768 and 1773, nine sail of ships of the line * were built, and a great number of frigates constructed, and repaired with timber which had undergone this process. In order to put the efficacy of the mode to the severest test, six pieces of elm pipe used for the purpose of conveying water, were prepared by Mr. Jackson, and laid down in October 1767, with some other pieces which had not undergone the process; when examined in June, 1775, those which had been boiled in the lixivium, were found to be equally as defective as those which had not been so prepared. The keel of the Intrepid which had also been, as it was termed, pickled, in the year 1767, was found on examination, in the year 1770, to be rotten. Upon a comparison of the durability of those ships, the timbers and plank of which had undergone the aforementioned preparation, with that of an equal number, taken promiscuously, which were launched shortly after the close of the war with America (1783),

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* The names of the ships of the line, the timbers of which were so prepared, are

98 Prince George.	74 Resolution.	64 Intrepid.
„ Princess Royal.	„ Grafton.	„ Monmouth.
74 Cumberland.	„ Bedford	„ Defiance.

and either lay in ordinary, or in port, fitted as guard-ships until 1793, the periods of durability are in favour of the latter. The deliquescent properties of some of the materials used, attracted the damp of the atmosphere, and the ships constructed of timber, so treated, were constantly in a state of damp vapour, which was highly injurious, not only to the metallic fastenings, but also to the health of their crews. It may, however, be right to remark, that the frame and planking of the Intrepid, which it has been conjectured was paid over with a solution of animal glue, was prepared in the manner before stated, by Mr. Jackson. So jealous were the workmen at that time, of the interference of any persons in endeavouring to increase the durability of ships, that they raised an outcry against the method, stating that in the use of the materials, and in working the timber, they were subjecting themselves to be poisoned; and so far did they carry their opposition, that the experiments were stopped, until Mr. Jackson had explained the process to the College of Physicians, and obtained a certificate from that body, that the articles made use of would not injure the health of the workmen. This mode of preparing timber was abandoned about the year 1773.

It had been frequently observed that the vessels, employed in the conveyance of quick lime, remained a great length of time in a perfect state; in the year 1798, Mr. White, who had been previously employed by Government in the construction of a floating battery, proposed to season the frame of a ship in lime; from the instances which he gave of its success, a favourable opinion was entertained of the plan, and that the experiment

might be conducted properly, it was ordered that the timbers of the frame on the larboard side and half of the beams, of the Amethyst frigate of thirty-six guns, then about to be built at Deptford, should be so seasoned, under the superintendence of the projector. It was observed that the timbers after they were taken from the lime-pit, were much rent, indeed some of them were rendered useless from this circumstance. The Amethyst was launched in April, 1799 ; and when examined for repair at Plymouth, in 1809, it was discovered, that the timbers of the frame and beams which had undergone the process were in a more defective state than those which had not been so seasoned*.

The indissolubility of charcoal has been remarked at all periods, even when it has been placed in the most trying situations; and wood, with a carbonized surface, has resisted for a very long time the influence of air and water in bringing about its destruction. In order to try the efficacy of carbonizing, or as it is usually termed charring, the timber employed in the construction of ships, it was directed that it should be tried on the alternate timbers of a sloop of war, comprised within half the length of one of her sides, and every six timbers alternately, within the other half of the length, and also the whole of the planking on that side; the timbers to be carbonized on the whole of their surfaces, and the plank on the interior surface only. The vessel selected for the purpose was the Dauntless,

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* Evelyn, in his *Silva*, book 3, chap. 4th, states the "burning and destructive effects of lime on timber."

then ordered to be built at Deptford, and she was launched December 1808. When this ship was examined at Portsmouth, in March 1814, it was found that some of the timbers and plank which had been charred were in a state of decomposition, with fungus growing upon them.

As the result of this experiment appears to be so different to what might have been expected, from the many instances that there are in ancient, as well as in modern times, to prove the incorruptibility of vegetable or animal substances when converted into charcoal, it will be right to examine into the probable causes of the failure. Charring of wood cannot be carried to a sufficient extent on the timbers of ships to be very useful, as from the action to which the materials are subject by the working of the vessels at sea, the carbonized surface would soon be crumbled and worked off, and thus the timbers and plank not being in contact, the strength of the ships would be greatly diminished. In the Dauntless, the timbers and plank might rather be said to have been smoked than charred. Perhaps the timber in this ship might not have been sufficiently seasoned; and if so, the action of fire is likely to have done mischief, by closing the pores of the outer layers of the wood, and thus forming an incrusted barrier to the escape of the vegetable juices, the internal decay of the timber would be the consequence. The openings made in the ends of the beams of ships, commonly termed the mouthings, have usually been charred, and the best results have been experienced. There is a disadvantage, however, that should be mentioned; the attractive power of charcoal for water, for it

has been found, that when exposed to the air after coming from the crucible, it will, in a short time, imbibe one twenty-fifth part of its weight of moisture.

Animal and vegetable oils have been made use of for the preservation of timber, but the former have been usually applied on account of the comparative low rate at which they can be purchased; the latter, however, particularly that expressed from linseed, are to be preferred, as being little liable to putrefaction; this mode of preserving timber was known to, and practised by, the ancients *. About the year 1756, Dr. Hales recommended that the planks on ships, placed between the light and load draughts of water, should be soaked in vegetable oil, to prevent the injury to which wood alternately wet and dry is subject, and also as a preservative to the ravages that worms usually make in that part of ships' bottoms, vessels at that period not having metallic sheathing; this was tried, in some instances with success, by preventing for a time injury from those animals. It is no uncommon thing to cut a hollow place in one of the ends of pieces of timber, designed for the beams or stern posts of ships, and to keep them continually filled with train oil; among other instances which might be cited, the beams of the Fame of seventy-four guns were so treated, and upon examination, when the ship was repaired, those parts of the beams where the oil had penetrated (but which was not more than from twelve to eighteen inches) were sound, while the remaining

* See Pliny, *Lib.* 16. *Cap.* 40.

parts were decayed. This principle of saturating in a degree the beams and other timbers of ships, has been much practised in America. The difficulty of impregnating wood with oils, particularly when it is charged with vegetable juices, has induced the recommendation of using a considerable degree of artificial heat, in order to force out in a gaseous form the moisture in the timber; and as fixed oils do not boil at less than 600 degrees, they have been the medium of seasoning, as well as impregnating the timber; but the wood which had undergone this process, was found to have lost much in strength, and its fibres were easily to be separated.

Upon the same principle vegetable tar has also been tried; pieces of wood, two feet five inches long, and one inch and a half square, were boiled four hours therein; and it was discovered, however, that it had not penetrated far within their surfaces; and when tried as to strength with other pieces cut from the same tree, and which grew in a similar situation, it was found that those pieces which had been boiled in tar, had decreased one-seventh.

A course of experiments is now being conducted upon a large scale, for the purpose of seasoning timber, and at the same time impregnating it to a certain degree with mineral tar, which from the ability and attention of the gentleman* who devised and superintends them, are likely to prove whether the plan can be advantageously employed. There remains no doubt, that

* Mr. Bill.

mineral-tar is far preferable to vegetable for this purpose, not only on account of its cheapness, but also as an incrusted coating is placed upon the timber by boiling, which being insoluble in water, will effectually prevent the absorption of moisture. And if it should be found requisite to take off any of this coating in working the materials, it is proposed to pay over the parts exposed with warm mineral tar. As wood is a bad conductor of heat, the desiccation is much promoted by boring a hole through the centre of each piece of timber.

In the year 1805, Mr. Mackonochie *, then residing in the East Indies, published a prospectus of a work on naval affairs, and recommended therein, that the different kinds of wood which do not contain oleaginous or resinous matter, should be impregnated therewith. He instances for the purpose, the chips and shavings of teak, or any of the woods which have terebinthinous properties; and states, that he then had in use for the purpose, a steam chamber, capable of containing from twenty to thirty planks, forty feet in length, or timber equal thereto in dimensions.

There appears but little doubt that this description gave the notion to Mr. Lukin of impregnating wood with oleaginous matter; and induced him, in the year 1811, to propose preparing timber for naval purposes, on an extensive scale, according to this method; the specimens which he exhibited, that had as he

* From the known ability of the author and the talent shewn in the prospectus, it is much to be regretted that the promised work never appeared. The prospectus is dated in 1803, but was not published until the year 1805.

said undergone the process, made so favourable an impression upon the members of the naval boards, that a seasoning-house was ordered, and it was ready for trial in January 1812. The length of it was thirty-two feet in the clear, the breadth twelve feet, and its height twenty-three feet, the walls were two bricks and a half, or one foot ten inches and a half in thickness; covered with Parker's cement on their inside, and with paint without; these were intended to prevent the escape, through the porous bricks, of the gases with which it was proposed to fill the building. The roof was an arch of brickwork fourteen inches thick, covered externally with slates, and the floor was of stone, laid at an inclination to carry off the condensed vapour. Without the building were fitted two retorts, with stop-cocks to throw the gas into the house, and a cast-iron furnace to heat them; from the latter there were flues nine inches in diameter, which passed along the bottom, and at the ends and sides, for the purpose of conveying and equalizing the heated air. There was also an oven to dry the materials before they were put into the retorts. To prevent accidents from an overcharge of gas, a safety-pipe twelve inches in diameter passed through the roof. Gasometers, thermometers, and hygrometers, properly stuffed to prevent the escape of heat, were fitted, so as to shew at the outside of the house, the strength of the gas, the degree of heat, and the state of the vapour in the building. There were at different parts waste pipes, to carry off the condensed vapour, and reservoirs to receive it, and measure the quantity.

On the 27th of March, 1812, a considerable quantity of timber

having been deposited in the house, the double doors which were of cast-iron were closed, and fires lighted; the heat varied in this and the following experiments, but it rose to 212° of Fahrenheit; the retorts were charged during this trial with pit-coal, and sawdust from pitch pine timber; the building was opened on the 14th April 1812, and it was discovered that the timber was either so much burnt or charred, as to be unfit for use. The failure was supposed by the projector to have arisen from a defect in the foundation of the house; this, by an alteration, was considered to be remedied, and on the 20th August, it was again closed, having only a small quantity of timber therein; the greatest degree of heat, was 150°, and when opened on the 14th September, the timber *externally* did not seem to have suffered injury.

The orlop beams, for the Nelson of 120 guns, were then placed in the house; these timbers had been previously covered with train oil, and the retort charged with the same liquid mixed with pit coal; the greatest degree of heat during this experiment, was 130°. The house was opened on the 26th October, but the timber upon examination not being found sufficiently dry, the doors were again closed, and the beams allowed to remain until the 3rd of November; when, however, they came under the tools of the workmen, they were found to be still in an unseasoned state, to account for which it was presumed by Mr. Lukin, that the fish oil put upon them, had retarded, if not in a great degree prevented, the escape of the moisture.

On the 17th December 1812, the house was again closed,

containing various kinds of wood, and the retort was constantly charged with pit-coal, and saw-dust from pitch pine timber; the greatest degree of heat was 119°; but on the 30th December, at about four o'clock in the evening, while the person, whose duty it was to attend the fires, and regulate the heat, was in the act of lowering a damper placed on the chimney, the carburetted hydrogen gas exploded and the building was destroyed. A short time before this occurred, the heat was at 106° only.

The accident was supposed to have been occasioned by some defect in the large flue, which during the action of lowering the damper, allowed the flame to pass through it into the house, where the carburetted hydrogen was in such proportion to the atmospheric air, as readily to explode. The shock occasioned by this accident was tremendous, and its effects fatal: an iron door weighing 280 pounds, was driven to the distance of 230 feet; a part of the wall of the dock-yard, although at a very considerable distance, was blown down, and some houses without the premises, which were in a measure protected by the boundary wall, unroofed. Six men were killed and fourteen much injured, two of whom died from the effects of wounds. The destruction of the building was so complete, that in few cases were two bricks left in contact.

The timber, seasoned according to this method, disappointed expectation; those pieces which were perfectly dry, although without the appearance, on their surface, of being rent, were rendered concave on each side, and when cut were found to be so much cracked internally, as not to be fit for any useful pur-

pose, and as far as opinion could be formed, the gases had not penetrated the wood; this experiment has not been repeated.

A marcasite obtained from the tin mines in Cornwall, and usually called mundic, is from its containing arsenic, prejudicial both to animal and vegetable life; this was stated by Mr. Constable in the year 1768, to be a preservative from worms, if pulverized and laid on the bottoms of ships in a state approaching to mortar. In the year 1812, Mr. Lukin recommended a wash of mundic in nearly the same way, as a preservative to wood from decomposition by fungi. This was practised on many of the timbers converted for the Queen Charlotte of 108 guns; when she was repaired at Plymouth; the workmen in applying it, could not prevent some coming in contact with their flesh, which being taken into their systems by the absorbent vessels, glandular swellings were the consequence, which caused the death of two persons. The like effects would arise from barytes if used for the purpose.

Some years since, active chemical means were employed to render oak timber, in a short time, similar in appearance and quality to that dug out of bogs*, but the attempt failed, by the projector not being able to carry the impregnation to any extent.

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* Professor Grassman of Stettin, about 30 years since, proposed the following method of rendering timber, used in the construction of ships, more durable, and also impenetrable to the worms. The oaks to be felled in the spring, and kept perfectly dry until their native juices were exhaled; the timber then to be soaked in a ley, prepared from mineral coal and turf, so loaded with styptic or rather antiseptic particles, that such an additional firmness may be given to the timber as shall make it more durable, and the materials with which it is imbued, possess qualities noxious to worms.

Covering timber with peat moss * has also been stated to have this effect. The wood, however, taken from bogs, when exposed to the weather, becomes weak in fibre, splits and is soon impaired in quality.

Having given an account of such means as have been tried on an extensive scale, and their results in preventing the decomposition of timber, also others which have been recommended for that purpose, it remains to be remarked, that the early decay of some of his Majesty's ships, constructed under unfavourable circumstances, having been very generally made known through the medium of the public prints, has induced a number of persons to pretend being in possession of secrets to arrest or prevent the decomposition of wood. As most of those who have made their pretensions known, have hidden the means under the veil of empiricism, it is probable that many of them are mere combinations of some of the ingredients mentioned in the former part of this chapter. In most cases permission has been given to the parties to prove the efficacy of their plans; with which view the prepared timber is left for twelve months in a pit in Woolwich dock-yard, in which, by its being lined with wood in a decomposing state, carbonic acid gas, so friendly to the growth of fungi, is generated; the temperature of this pit is raised, in order to promote fermentation, by placing horse-litter fresh from the stable over the lid: it may be observed, however, that no specimen has yet been put into this pit, except the wood has been insulated by any substance, which has entirely resisted the influence of the gas.

* The sulphates of iron, soda and magnesia, are found sometimes as the ingredients of peat.—Dr. HENRY.

CHAPTER V.

ON THE PRACTICAL AND THEORETIC CONSTRUCTION OF SHIPS, AS TENDING TO THEIR DURABILITY.

ALTHOUGH it does not come within the province of this work, to give a detail of the theoretical or practical rules and methods for the construction of ships; yet, as it is considered that both have an influence in their durability, it may be proper to advert to the principles on which this depends.

An uneasy ship at sea can never be durable; the violent actions to which she is constantly subject, must naturally loosen the fastenings, disjoint the pieces of which the fabric is composed, displace the caulking between the planks, and subject the vessel to partial leaks, in particular in the upper-works, where the effects of a violent momentum are chiefly felt.

Hard pitching of ships at sea may be occasioned by precautions not having been taken, to balance properly the fore and after-bodies, and to give to the former its due preponderance of displacement *; or it may arise from the bow and stern being

* The fore-bodies of ships, taken from the middle of their lengths, at the load water-line, should have about four *per centum* of the whole displacement more than their after-bodies. For instance, if a ship of the line displace 3,000 tons, her

unusually slender, or what are termed lean, or finally it may have its origin from the foremast being placed too far forward.

Rolling to a great degree, or jerking, is a motion which much injures ships; it may arise from their midship bodies being very round or approaching to segments of circles, by the masts and yards not being proportioned to overcome to a sufficient degree, the resisting power of the water on their bodies, which is technically termed, not being masted up to their stability *, or

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fore-body should have 1,620, and her after-body 1,380 tons of that displacement. Some, however, of the ships of the line of two decks, that are esteemed good ships, have as great a difference as six *per cent.* of displacement between their fore and after bodies.

* The stability of a ship depends as much upon the formation of the lines of the body immersed, their area at and immediately above and below the line of fluitation, and upon the weights above water not being too great or raised unnecessarily high, as upon a correct proportion of breadth to length, which proportion depends upon the number of masts to be placed in the ship. In ships with three masts, it may vary from 3.75 to 4. breadths for length; but it should not exceed the latter, because the ships would not be found to work quickly. During the seventeenth century, little of the principles of ship-building were known; Mr. Pepys states, in 1673, that, "before that time, the builders in England had not well considered, that breadth *only* will make a stiff ship;" and this he, who was furnished with the best information of his time, gives without a consideration of proportion, or adverting to the inconveniences of great breadth in increasing resistance, &c. Experience has proved that those ships of the line in the British navy, which have a sufficient displacement to carry their lower deck-guns sufficiently high (six feet) from the line of fluitation, with the less proportion of breadth to length, keeping it, however, within the limitation aforementioned, have proved to answer best; so that the giving an increase of length to breadth, may be considered among the improvements made in naval architecture during late years. It has been a practice when ships have been wanting in stability, to double them at, and for some feet above and below fluitation, the doubling to extend all fore and aft, but to wear off at the stem and stern post to about four inches in thickness, and below the line of fluitation, to make a fair line with the plank of the bottom. The Cumberland, of three decks, and eighty guns, was so doubled at Portsmouth, in the year 1697, with ten-inch thick-

by an injudicious stowage. Fast-sailing ships of war appointed as convoys to merchant vessels, are much strained by rolling, arising from their not being able to carry a sufficient quantity of sail, as a balance to the opposing power of the water, from the fear of deserting the ships under their protection. Uneasy motion may also be occasioned by an irregular increase of stability, or from the immersion and emersion at different angles of inclination, not being properly balanced.

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stuff, which was called girdling; this ship was captured by the French in the year 1707. Sutherland, in his work called *Ship-building Unveiled*, published very early in the eighteenth century, states, "that the Royal Katharine, of three decks, and eighty guns, contrived by the Royal Society, was girdled." Notwithstanding these authorities, M. Romme, in his *L'Art de la Marine*, gives the merit to the French, in putting, in the year 1779, a doubling of twelve inches in midships, and wearing it off to four inches afore and abaft on Le Scipion, L'Hercule, and Le Pluton, of seventy-four guns each, which ships were built by the same plan, and found to be much wanting in stability, and he calls it *cette nouveau correctif*. This method has also been practised lately; the Boyne, of 104 guns, was doubled at Portsmouth to increase her stability in the year 1813. The practice of placing doubling on ships, not only gives them an increase of stability, but also strength, in a part where it is much required, *viz.*, at, and a little above and below the line of water. With the latter view Mr. Snodgrass, who for many years filled the office of surveyor of shipping to the East India company, gave, as his opinion, in the year 1792, before the commissioners of Land Revenue; that no ship should have a thorough repair, but instead of this "that their bottoms and upper works should be doubled with three-inch oak plank, from keel to gunwale, and strengthened with knees, standards, and even with iron riders, if necessary, all which may be done at a small expense; and ships so repaired would be stronger and safer, and be able to keep the seas longer in the worst weather, than any new ships in his Majesty's navy." In 1805 twelve sail of the line and eleven frigates were doubled with 3 inches oak plank, and some of them had diagonal braces in the hold; their average time of service was about six years, the diagonal braces were found, by giving partial strength only, and acting as a shore to force out the sides, to be dangerous and detrimental to the ships.

Too much attention cannot be paid to the theoretic construction of ships; it is the little difference in lines, unobserved by the unskilful in this branch of science, that causes the great difference between vessels of the same class; and the navy of England has furnished numerous examples to prove, that ships, the lines of which are constructed upon true theoretic principles, may remain in service many years without any outward appearance of weakness, although internally the materials of which they were composed, may exhibit all the symptoms of a general state of decay; while others, from the violent motions to which they have been subject from a faulty construction of their bodies, have been weak after a short period of service, and constantly afterwards requiring repairs; for whatever skill may be exercised in putting the ships together, or however good the principle may be, on which they are built, yet, if the motions of pitching and rolling be heavy, they must in a short time become weak, leaky, and consequently subject to early decay.

The practical construction of ships of war has within a few years, undergone a complete change *, which is likely to be conducive to their durability. To prevent arching, or, as it is sometimes termed, hogging, occasioned by faulty construction, or by what must always be the case, an unequal distribution of the weights at different sections of a ship, compared with the quantity of water displaced at those places; the footwaling, or in other

* The present system of building the ships belonging to his Majesty, was invented and introduced by Sir Robert Seppings, surveyor of the navy, and is given at large in the *Philosophical Transactions*, for the year 1814, part 2d.

words, the ceiling, and vertical riders in the hold are omitted; but the frame is made solid from the keel as high as the orlop clamps *, by driving in between the frame timbers on their outer surfaces, pieces of dry wood about three inches in thickness, placing thereon from the inside, cement, composed of two parts of Parker's Roman cement, and one part of drift sand, (and bricks are put in those openings that are wide enough to receive them,) and then driving on that, wood three inches in thickness, to make the internal surface fair. Caulking is then introduced between the frame and filling both within and without board; by this it may be said, that the whole thickness of the timbers assimilates to the plank of the bottom, for by being water-tight, if the outer planking were displaced, the safety of the ship would not be endangered †. Over the timbers is placed a framing, formed of riders, lying at an angle of 45°, with shorter pieces, called trusses, between them, which altogether, form a series of triangles, that constitute what is called a diagonal trussed frame ‡.

* In the year 1762, Mr. Kirby of Chatham-yard, proposed "to fill in and caulk the frames of ships from the water's edge to their bilge, and to caulk also the footwaling," but his plan was not carried into effect. And M. Charles Dupin, in his essay "*De la Structure des Vaisseaux Anglais*," inserted in the *Philosophical Transactions* for the year 1817, part 1st, proposes that ships should be filled in to their topsides, not only to strengthen them but more effectually to resist shot.

† Filling in of ships, is likely to prevent the great mischief that would otherwise result from explosion, if that insidious instrument of war, the torpedo, were employed against them. Machines of this nature are of American invention, and were used with some effect in the first American war, (1776.) Although attempts were made by the Americans during the last war, (1813,) to destroy the British shipping with machines of this nature, they failed in accomplishing their object.

‡ In frigates and smaller vessels, iron plates lying at an angle of 45° in the direction of the trusses, are substituted for the diagonal trussed frame.

To prevent injury from the stress downwards, exerted by the main mast, and to take off the longitudinal pressure of the water upwards on those floors which lie nearly horizontal, two additional keelsons are worked, extending for a considerable distance in midships, and lying parallel with the main keel.

Transverse breaking, or separation from lateral pressures by the waves, or by the action of the shrouds upon the sides of the ships, is, in a great measure, prevented by a more general union of the timbers and plank by shelf pieces acting as internal horizontal hoops, on which the beams rest, and to which and to the thick waterways above, they are connected with coaks*, and also by bolts passing through the whole; their junction to the sides, is made complete by a chock under the ends of every beam, and a clasp hanging iron knee † attached to its frontside, bolted to the shelf piece, the beam, and the side.

The planks of the lower, middle, and upper decks, are laid diagonally, with their ends on one side, resting in a rabbet cut

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* Coaks or dowels, both of metal and of wood, either round or square, have been used for many centuries in works of civil architecture, to connect pieces of stone or wood together without the trouble and expense of tabling; they were introduced partially into ships by General Bentham, and are now successfully employed to a great extent in most of the operations of naval architecture.

† In the year 1806, a mode of attaching the beams to a ship's side by a chock under them, and plate knees on each side, was introduced into the service by Mr. Roberts, now master shipwright of Pembroke yard. Similar plates were, if not invented, described by Du Hamel in the year 1758, in his *Elemens de l'Architecture Navale, Cap.* 1. *planche* 2, and have been long used in partial cases by the Dutch and Danes. It was found to be an expensive mode of fastening, to accelerate decay, and in consequence of the working of the ships to split the beams, by the bolts running in a right line in the direction of the fibres, and has therefore been discontinued.

in the water-way, and abutting at the other, against thicker planks worked in midships; these also prevent in a degree, a lateral alteration in form, and afford great facility by allowing deals or oak plank of any lengths or breadths to be worked into the ships. The timbers in the bow, are carried up to the height of the topside, which forms a round bow, and the stern is circular, assimilating in the mode of timbering to the bow.

Between the ports, instead of placing horizontal planks, or as they are termed short-stuff, trusses are introduced, lying in a diagonal position, and which tend with the framing in the hold, to prevent arching*. It should have been stated, that the several timbers of the frame are reduced in length, and, therefore, in curvature; that they are converted with square heads and heels, connected with coaks, and that they are all framed in bends; by reducing the length of the timbers, and discontinuing chocks, cutting across the grain is avoided, and thus the durability of the timber promoted. For it is a common

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* To prove the efficacy of the plan of trussing ships, it was tried in a temporary manner in the Justitia of 74 guns, built in Denmark in 1777, and captured at Copenhagen, 1807; the ship being old, the materials were in general decayed, the fastenings loose, and she was so much broken in her sheer, that when taken into dock upon streight blocks, an alteration took place of two feet three inches and a quarter, in each half of her length, and when undocked with the trusses placed, she broke one foot two inches and five-eighths. Twenty-four hours produced a further breakage of two inches and five-eighths. The temporary trusses in the hold were then disengaged, and an alteration of six inches immediately took place in the sheer of the ship; when the trusses which were placed diagonally in the ports were taken out, she broke four inches, thus bringing her to the original sheer. A great compression of the diagonal pieces was every where visible.

observation among ship-builders, that all timber which has been grain cut, decays much more rapidly in any situation in which it is placed, than that which has not been so cut.

The distinguishing difference between the old and new principle of ship-building is, that in the former, the materials in general were laid at right angles to each other, in the latter a considerable proportion of them are placed diagonally; so that the strains are supported by the longitudinal strength of the materials, in resisting the compression or extension of their fibres, instead of their being acted upon laterally, in which direction their strength is the least. This principle is in the highest degree advantageous, both in the employment of wood and metals.

A general distribution of strength has also been attended to, for no axiom is more true, than that "partial strength in any machine is general weakness." Notwithstanding this, there has been a mistaken notion with some ship-builders, that loading the top-sides of ships, particularly those which are weak either from age or other circumstances, with iron knees, iron standards, riders, *&c.*, remedied the evil by adding to their strength; this country, however, has found by dear-bought experience, that the additional weight not only increased the weakness, but ruined the sailing qualities of the ships. Lightness in materials, above the line of fluitation, is a principal characteristic in the new mode of ship-building.

Ventilation is with difficulty accomplished in the hold of a ship, and the openings which were formerly left between the

timbers, were filled either with deteriorated air, filth, or the larvæ of insects. Some doubts were entertained, when the present system of ship-building was introduced, whether the timbers in the hold when filled in, would not be subject to premature decay; but this objection, which is contrary to theory, has been proved by experiment to be totally without foundation; for when the Tremendous, and Ramillies, rebuilt upon this principle, were opened for examination, the timbers which were filled in, were perfectly sound, while many of the others in their topsides were decayed.

Dr. Hales, so justly celebrated for his works on natural philosophy, states, that "the closer the timbers are to each other, provided they are not so close as to exclude any degree of air, so much the sooner are they apt to decay; thus the confined air between the outer and inner lining of a ship, and between the outer planks and ribs, destroy those timbers, and corrode the tree-nails asunder like *aqua-fortis;* so that, whenever we see timbers when laid open, decayed, we may be sure it is done by that most subtile and powerful dissolvent, close, confined, putrid air *." Dr. Henry, in his excellent work, *The Elements of Practical Chemistry*, has observed, "that when excluded from the air, even moist wood shews very little tendency to decomposition.

In order to render that part of the ship which is filled in

* Dr. Hales gave the designation of "putrid air" to that description now called carbonic acid gas.

impervious to air, and to prevent water being injurious to the durability of the wood, by being held between the timbers and plank by capillary attraction, as much coal-tar *, as can be injected by the power of a forcing pump, is thrown therein; this fills up any interstices †, and being insoluble in water, prevents absorption, dislodges the foul air, and by its antiseptic quality, it is probable, creates a new and wholesome atmosphere.

It, however, becomes a question, how far it may be proper to use coal-tar in that part of the ship, which is appropriated for the reception of bread; and also in merchants' ships, which carry cargoes that would be injured by the taste, or from the smell of the volatile essential oil, which the tar contains. Bread, however, would be better preserved against all accidents, if it were kept in cases of cast or wrought iron; by this mode much

* Becher, to whom chemical science is so much indebted, in his works published at Francfort, in 1683, says, "he had succeeded in adapting to common purposes, the inferior kinds of turf of Holland, and the inferior coal of England, and procured from them a tar, superior to the Swedish; he had made it known in England, and shewn it there to the King." Lord Dundonald partially introduced coal-tar for naval purposes in the year 1785, and it was found by many experiments to be in all cases equal, and in most superior, to vegetable tar; but it was not until large quantities were produced from the works for procuring carburetted hydrogen gas, for the purposes of illumination, that it was used generally in the naval arsenals.

† The evil arising from openings in which air cannot freely circulate, was shewn in the renewal of a practice which prevailed in the navy at the early part of the eighteenth century, that of cutting small scores or channels on the faying surfaces of timbers and planks, and which was called "snail-creeping." This had been practised on the Royal William, rebuilt 1719. But when recently carried into effect in Chatham-yard, it was found, that the interstices so formed, were in a short time full of fungus.

benefit would be derived, and in the end a great saving produced.

For the purpose of preventing the decomposition of timber by moisture, where two surfaces come in contact, or as they are technically called the faying surfaces, they are covered either with a mixture of oil and tar, or with paint; the pigment used for the purpose is commonly white-lead *; and such coaks as are made of wood, are soaked in oil, and have their ends painted.

Ventilation from the upper works to the orlop deck, is effected by the open spaces left between the decks above, and shelf pieces † below, also by the omission of short-stuff and substitution of trusses between the ports, so that the openings between the timbers form channels for the circulation of air, which contributes to the preservation of the wood, and to the health of the crews belonging to the ships.

Much discussion has at different times taken place, whether tree-nails or metallic fastenings are the best to be applied

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* A mixture of oil and charcoal finely powdered, has been recommended for this purpose by Mr. Chapman, but it has not been put in practice.

† It is but justice to acknowledge, that the great benefit which naval architecture has derived from the introduction of shelf pieces, is due to the French. These pieces not only give general strength by a better combination, but serve as a substitute for lodging, and in a great measure for hanging knees to each deck. As a proof, the Malabar, of seventy-four guns, built at Bombay, brought home (under jury masts) a large cargo of teak timber, and as iron work is expensive, and but indifferently executed in India, all the knees were omitted; the ship on her passage home, from an excess of stability, was subject to violent motions, and encountered four severe gales of wind, yet there had been no apparent motion or working, in the materials for the want of knees. The Malabar is the first ship built at Bombay, on Sir R. Seppings's principle.

generally in ships, not only as increasing their strength, but prolonging their duration. Tree-nails were no doubt introduced from the consideration that iron is much subject to corrosion by the action of salt-water, and there is every reason to believe, that their use is nearly coeval with the British navy; although official documents do not afford this information, yet mention is made of them in a paper bearing the date of the year 1552. Independently of the bolts which pass through the outside plank, for the proper security of riders, chocks, shelf pieces, *&c.*, worked within board, there are others put into the ends of each plank in the bottom, called but-bolts, and a few shorter ones named dump-bolts, which are used to keep the planks in their places; the remainder of the fastenings are tree-nails.

The arguments advanced against the use of tree-nails are, that they are weak, (iron being eleven times, and copper six times, the strength of oak,) that they are subject to early decay, and by capillary attraction, water passes through them to the injury of the ships. Mr. Mackonochie in the year 1803, in the prospectus before alluded to, strongly reprobates their use. Notwithstanding the objections made to them, all the European * nations apply tree-nails, particularly in the bottoms of their ships, in a greater or less proportion; and when cut from good timber and properly dried, they have been found to be very durable. In order to facilitate their seasoning, it was the practice in the

* The Dutch, during the seventeenth, and in the early period of the eighteenth century, imported their tree-nails from Ireland. The oak grown in that country, being tough and strong, was found to be the best for the purpose.

early part of the eighteenth century, to boil them in salt water, but it is a custom not to be recommended, as it will weaken the fibres of the wood. If tree-nails be properly seasoned and then driven tight, they seldom leak, as moisture will increase their bulk, and the compression of the fibres prevent the introduction of water into the ships.

Iron, from its superior strength, and the cheap rate at which it can be obtained, compared with other metals, was chiefly used on ships where metallic fastenings were introduced, until the year 1783, at which time the copper sheathing of ships' bottoms became a general practice; it had been discovered by the partial trials previously made, that where the two metals came in contact, and the operation was aided by sea-water, that a speedy corrosion of both took place; and the government then ordered that all bolts under the line of fluitation, should in future be of copper. In the use of iron bolts some disadvantages were experienced; when corrosion first took place, either by the gallic acid in the oak, by sea-water, or the combination of both, its volume increased, but after some time had elapsed, the metal became diminished, the fibres of the wood through which it had passed injured by the oxide, and the ships were leaky, or what are termed "bolt-sick."

Copper bolts have also their disadvantages, as the oxidation injures the timber, though in a less degree than iron, the volume of the bolts decreases, and the verdigris, which is formed by the action of the acid of the oak on the metal, prevents the adhesion of the bolts to the wood; hence the ease with which a copper

bolt may be displaced by percussion, and the partial leaks generally observable from bolt holes, where these fastenings are used.

Mixed metal * bolts, (copper and tin in the proportions of four of the former to one of the latter, with sometimes a little zinc added thereto) have been employed to fasten the bottoms of frigates built of fir; these were in the shape of large round nails, which were denominated, on account of the brittleness of the metal not admitting of their being clenched, "bolt nails;" these from the rough surface that they presented, and their not being so liable as copper to oxidation, held well, and did not injure the wood. The brittleness of mixed metal is, however, an objection to its general use for this purpose.

To save expense, hollow copper bolts have been tried; they required a socket punch to be used in driving them, and much difficulty was experienced in forming a clench over a ring, for which reasons they have not been introduced into ships.

Hollow screws, (to be used instead of tree-nails and bolts,) made of mixed metal, were recommended in the year 1808, by General Bentham; the mode of passing them into the wood, was by means of a key; and when in place, the hollow core was to be plugged up. Solid screw bolts were also used, by directions from that gentleman, on some vessels built after his plan in the year

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* The use of mixed metal fastenings in ships is of an ancient date, for, according to Vegetius, brass was used by the Romans instead of iron for the bolts and nails applied in fastening their galleys.

1796, but were not found to answer. It is, however, considered, that copper bolts well driven and clenched on a ring, are far preferable to any others when used under water.

In the year 1815, Dr. Pellet, proposed to coat iron bolts with zinc, as a cheaper and stronger fastening than those of copper; upon trial, however, it was found, that iron when newly rolled in its black state, would not take the zinc, that it was necessary to file it bright, in order to effect the coating, and that the zinc required to be brought to a great heat, so as to be in part volatilized, before it would adhere to the iron. So much workmanship was required, that the price of the bolts so prepared was nearly equal to the value of copper, and the zinc was displaced from the head, and some other parts of the bolts by driving them; the experiment was therefore abandoned. Bolts formed of zinc were proposed in the year 1816, by a M. Chaulet, who stated, that they had been used with success in France; but no trial thereof was made, as it is known that it is very brittle, more affected by muriatic acid than copper, and possesses only one-third of its strength.

In the year 1779, about five tons of several kinds of bolts were purchased of a Mr. Kier, by way of trial; some of them iron, covered with a sheath of copper; others a mixture of copper and zinc, usually termed gun metal; and the remainder a combination, as it is supposed, of metals, the names and proportions of which were not ascertained. A considerable quantity of these were used on the Standard of sixty-four guns, built in 1782; and when that ship was taken to pieces at Sheer-

ness in 1816, the iron bolts which had a covering of copper, and also those of brass, were found to be in a good state; but the bolts, the composition of which the maker did not disclose, presented the most extraordinary appearance. They had not decreased in size, nor was there any alteration in smoothness of surface, but they had so completely lost their tenacity, that the slightest blow was sufficient to fracture them, and when broken, they had all the appearance of brown pottery ware; upon being cut, there were in some places, particles of a red shining metal, resembling copper, but their extreme lightness proved that but little metal remained.

Copper nails of a square form have also been used for fastening the bottoms of ships; in England this practice has been confined to those built of fir. But in France, they have been employed on ships and vessels built of oak; those in use in both countries, after passing through the bottoms, go about five or six inches into the timbers of the ships. The Spaniards use very long nails for the purpose, which pass through the timbers and are turned on the inner lining*; nails have this disadvantage more than other metallic fastenings, that they frequently split the plank of the bottom.

The ends of bolts have had, in some cases, a worm cut on them, and nuts have been placed thereon as substitutes for clenches; these were introduced generally in a French brig of war, La Ligurienne, captured in the year 1800, by his Majesty's

* This method has also been practised in some ships built in the East Indies.

sloop Peterel and carried into Plymouth. The use of nuts and screws on bolts has been recommended, under the notion that if the shelf pieces, planking, *&c.*, should not set close to the timbers of the frame, either from the working of the ships or the shrinkage of the materials, they might be drawn into contact by the nuts. This, without examination or trial, would appear feasible, and in some cases might be effected if all the bolts lay parallel, but as this is seldom the case, the screws become useless, and the endeavour to heave them up, only destroys their worms. The adhesion, too, of iron bolts is so great, in consequence of the increase of the volume of the metal by oxidation, and by the shrinking of the fibres of, perhaps, unseasoned wood round them, that in many cases where instruments are employed to extract them, they are drawn asunder. The softness of copper will not admit of a great strain to be put upon any worm cut in that metal; and under any circumstances, if the bolts happen to be bent, it would be found impracticable to move them or the materials through which they pass. The Dutch, in the year 1816, built two brigs of war, and used bolts with screws on their ends and nuts on them, but it is not their intention to continue that practice *.

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* The author had the information from Mr. Soutimer, the master shipwright of the royal yard at Amsterdam, a gentleman deservedly held in high esteem in Holland, for his practical experience in ship-building, as well as theoretic knowledge. His opinion is, that the use of nuts and screws on the ends of bolts was found by practice not to justify the expectations formed of the plan; for in carrying on the building of the vessels in question, it was proved, that good work could not be effected by them.

Under all circumstances, it appears that the present method of fastening ships generally with tough, well-seasoned tree-nails, with their ends split and caulked after being driven, and securing the buts of each plank with copper bolts well clenched, is liable to fewer objections, and more conducive to the durability of the timber, than any other which has been tried, or proposed to be substituted.

CHAPTER VI.

PRECAUTIONS USED WHILE SHIPS ARE BEING BUILT, TO ENSURE THEIR DURABILITY.

AMONG the many improvements, which have been introduced within a few years in the royal dock-yards, tending to promote the durability of the navy, none, from their importance, deserve more notice than the permanent roofs, which have been recently placed over the docks and slips, to protect the ships while being built or repaired, from the vicissitudes of the weather.

It appears an extraordinary circumstance, that in Great Britain, whose naval superiority is acknowledged, an improvement in her arsenals, the advantages of which are so evident, should not have been earlier carried into effect

At the commercial port of Venice, formerly the seat of trade, the ships whether built, building, repaired, or repairing, were protected by roofs. According to the evidence given before the Commissioners for Land Revenue, in the year 1792, by Mr. Strange, who had resided at Venice for many years in the capacity of British consul; there were then many slips and basins housed over, which had been so protected for a great

number of years *. At Carlscrona, as appears by a work published at Stockholm in 1764, there are seven covered docks, the projector and architect of which, was Mr. Dan. Thunberg. At Cronstadt, ships are also built and repaired under cover. And M. Necker proposed to the King of France, (Louis XVI.) in a *projêt* for finance, that roofs should be erected over the docks and slips; and in consequence, one was built over a dock at Brest. This practice has been recently extended to all the French ports in the British channel, and there are now (in the year 1820,) five slips at Rochfort, roofed over. The Dutch, too, have not been negligent in introducing this improvement, there being at present at Rotterdam, four slips roofed over.

In this country, in the year 1774, Mr. John Simmons, in a pamphlet he then published, strongly urged the measure as a matter of the greatest expediency; and in 1791, the Navy-Board, Mr. Snodgrass, Mr. Nicholls, Mr. Binmer and others, stated before the Commissioners for Land Revenue, as a matter of policy, to ensure the durability of ships, and thereby in the end, to save the oak-timber, then considered to be very scarce, that all ships should be built under cover. But the introduction of

* The Venetians had a dock covered over in the fifteenth century, under which was kept their superb galley, the Bucentaur. The author has been lately favoured with a sight of a laborious work in manuscript, on naval affairs, but chiefly on the construction of galleys, written and the plans drawn by M. Barras de la Penne, a page to Louis XIV, King of France, and dedicated to that monarch: it occupied nearly sixty years of his life, and was completed in the year 1698; in which is given drawings of sheds over docks and slips, some supported by wooden standards, and others on pillars of stone.

permanent roofs, is due to the indefatigable exertion of Sir Robert Seppings, who, when he became Surveyor of the Navy, in the year 1813, was instructed to keep the ships dry during the time they were being built or repaired; he, therefore, represented and enforced the propriety of this measure, and it is to his judgment that we owe, the novel and strong method of forming and framing those buildings *. But before this method was carried generally into effect, the plan in question, together with many others submitted by different individuals, was transmitted to Mr. Rennie, the celebrated engineer, for his preference and opinion; and as he considered Sir R. Seppings's to be decidedly superior to the others, his method of framing them has been introduced into all the dock-yards.

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* The buildings in question are curb roofs, and a section thereof is formed of two principal rafters, supported by two standards; the rafters resting upon the standards, at about three-sevenths of their length from the outer ends, and instead of running up to meet, a collar or horizontal beam connects their upper ends, properly supported by a king-post and two struts, which are connected to other rafters placed above that beam; the latter, however, have a much less degree of slant, their angle of inclination being only thirteen degrees, when that of the principal rafters is 34 degrees, thus lessening considerably a useless height of apex. Pieces of timber called braces are introduced, so as to extend on each side from the middle of the collar beam, to the centre of that part of the principal rafter which lies between the standard and beam; and from the *same point* of the rafter, a strut is placed to extend to the standard, abutting against it at about fourteen feet from its upper end. A strengthening piece is also introduced on the underside of the principal rafter, at the point where the truss and strut meet. A junction is formed throughout, between the rafters, trusses and struts, by a series of king-posts, which give great strength and stability. There are projecting eaves to protect the workmen and materials from the weather; these are supported by two struts on each side, the lower ends of which abut against the standards, the one a little above, and the other a little below, the inner strut; thus forming a balance of the outer and inner pressures.

Between the years 1788 and 1791, temporary roofs were placed over the following ships of the line, while they were being built; Royal Sovereign, Cæsar, Leviathan, and Minotaur; but the works on them were too far advanced, before they were erected for those ships to derive all the benefit that might otherwise have been expected; yet, notwithstanding this circumstance, they proved to be durable ships. At Chatham and Plymouth dock-yards, it was a custom to place a framing covered with old canvass over the docks in which ships were repairing; that served in a great degree to protect them from the weather, which at the latter port in particular was the more requisite, from the great quantity of rain which falls there, at all seasons of the year.

In foreign countries, the permanent roofs were supported either by solid walls of brick-work, or masonry, or they rested upon pillars of stone *; but those which have been built in England, rest solely on the poles (or standards, as they are called,) which are erected on either side of the slips, for the purpose of having the spars attached to them, which support the stages on which the workmen stand to plank the ships without board. The first temporary, as well as permanent coverings, supported by standards over docks, were erected in Plymouth dock-yard, the former in 1812, the latter in 1814.

Under the eaves which project on each side, the beams are put

* At Rochfort there is a slip covered over, the roofing supported by standards; this has been erected many years.

in an erect position, and the other materials stowed away, during the time the frames remain to season*. The first building of the kind erected over a slip in this country was at Deptford dock-yard, in the year 1814; the practice was immediately after followed in the other naval arsenals, and at the present period, all the slips, and those docks which are set apart exclusively for the purpose of repairing ships, are housed over. The dimensions of the largest roof over a slip are as follows: length, 245 feet; breadth, from standard to standard, 100 feet; projecting eaves on each side, twenty-five feet; making the extreme breadth 150 feet. Height from the ground line, along-side of the slip to the apex of the roof, at the head of the slip, sixty-four feet eight inches; at the stern, sixty-six feet ten inches. Moveable shutters in some cases, and canvass screens in others, are placed at the openings in the ends of the roofs, in order to prevent too great a rush of wind, which would cause the timber to crack. And on the buildings there are windows, which admit a sufficiency of light, to enable the workmen to pursue their several avocations. The roofs are in general covered with boards, over which is placed either tarred canvass, tarred paper, slates, or thin sheets of copper; the latter is a mode much practised, and generally preferred. There is in Woolwich dock-yard, over a small slip, a very neat covering formed of

* It has been usual, since the year 1771, for the frames of ships of the line to stand twelve months, and those of frigates to remain six months, to season.

plates of iron, which was put up by Mr. Wellington of Bristol, and it appears to answer the purpose *.

The introduction of the roofs, has been attended with the greatest convenience to the artificers; they are now enabled to work at all times, and during all seasons, without the inconvenience of rain in winter, or the heat of the sun in summer; and being thereby enabled to do more work with less fatigue, the price of labour may be fairly decreased, and by this alone the sum laid out in building these sheds will be saved in a few years. The expense of erecting one of the largest of the roofs over a slip, and covering it with sheet copper, amounts to 14,000*l.* The copper forms, however, one half of the expense.

It is to be hoped, that the advantages which have been enumerated, will induce merchant ship-builders to roof over their slips; this would be attended with the greatest advantage in point of durability, to the ships constructed under them, be a saving ultimately of that valuable article, English oak timber, and a conveniency to their artificers. And it is to be wished, if the Government should be obliged again to resort to the merchants' yards for the building of ships, that such persons only should be allowed to have contracts for constructing them, as have, or will put up, roofs over slips †.

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* The first ship of the line, launched in England from under a permanent roof, was the Wellington of 74 guns, built in Deptford yard; this took place in September 1816.

† Antecedent to the reign of Henry VIII., who established royal dock-yards at Woolwich, (which Camden calls the "mother dock,") at Deptford, and at Ports-

The strictest attention is observed in the removal of all the *alburnum*, or sap-wood, from the timber, during the progress of the works on ships, long experience having proved, that this is subject to early decomposition*; and that it is frequently the cause of the decay of the heart of the wood, and of the growth of fungus. To such an extent is the removal of this soft, spongy, imperfect wood carried, that if the planks can have a bearing on each timber of only one-third of its siding, it is considered preferable to work them with this, than to allow any sap-wood to remain on their edges.

The greatest precautions are taken, during the building of the ships, to keep the openings between the frames, and every other part, clear from chips, dirt, or any thing that would obstruct

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mouth; ships were either furnished by the Cinque Ports, hired into the service, or constructed by contract. Building the King's ships by merchants, has at all times been deprecated; sir Walter Raleigh, during the reign of Elizabeth, stated that it was an impolitic measure to construct large men-of-war except in the royal yards; and recently the rapid decay of ships of the line built by merchants, has been many times the subject of animadversion. It is, however, right to remark, that the materials of which most of them have been constructed have been of the best quality; and although in some particular instances, which it would be invidious to mention, defective workmanship has been discovered, yet excellent ships have been built by contract; and if equal time were given for the seasoning of the wood, and the ships were protected while being built by a roof, there is no reason to believe that they would be less durable than those constructed in the King's yards.

* "In most trees next the skin, lays the fat; this is nothing else than white sap wood, which from its colour, is called in Latin, *alburnum*; as it is soft in substance, so is it the worst part of the wood, and even in the strongest oak, hard as it otherwise is, it soon putrefies, rots and is quickly worm-eaten; and therefore if you would have hard and good timber, this white wood must always be cut away in squaring."—PLINY, *Lib.* 6. *Cap.* 28.

a free circulation of air in those parts where ventilation can be effected; great benefit has been derived from this practice, for no substances are more prone to putrefaction, if in a damp state, than saw-dust, shavings, and chips.

Several plans have been in use at different periods, for the purpose of bringing the planks round the bows and sterns of ships without splitting *, and to make them set well to the timbers, in those and other situations. It was the practice until the early part of the eighteenth century, to burn their inner surfaces, by exposing them to a fire made of bavins and old ship timber, and during this operation to keep the outer sides wetted with water; this was attended with considerable expense, both for fuel and labour, which induced Mr. Cumberland, in the year 1719, to propose a "stoving machine," which was to supple the timber by placing it in sand, moistened with salt-water. This plan was carried into effect, and he was allowed one-tenth of the saving during a period of fourteen years, provided the sum did not exceed 200*l.* per annum. The machine remained in general use until 1736, when Mr. Boswell, a purveyor of timber in Deptford-yard, proposed to place the planks in trunks, into which the steam of boiling-water was introduced, a mode that has been continued to the present period, chiefly for timber and board employed in the building of boats.

In the year 1744, boiling troughs were first placed in the

* The Dutch ships are usually very round and full in their bows and buttocks, and to prevent injury to the thick-stuff in bringing it round, it is common to run a saw-kerf through the centre.

dock-yards: and from that time to the present, planks have been boiled as many hours as they measure inches in thickness; at some periods it has been usual to use fresh, at others sea, water, for this purpose.

If the planks be well-seasoned, burning appears to be the best mode of bringing them round, as it is done with ease, and they always present a dry, if not a carbonized, surface to come in contact with the timbers of the frame. But, if on the contrary, the planks are unseasoned, boiling in fresh-water is thought to be preferable, as it enters abundantly into the timber, and carries off a considerable proportion of its juices. By dissolving some of the principles* of the wood, its strength is certainly decreased; but this is to be preferred, when necessity compels the use of green timber, rather than fermentation should be promoted by its containing, when worked, a great quantity of vegetable juices. Planks that have been well-seasoned, uniformly weigh more when taken out, than when put into the boilers; those which are unseasoned, considerably less.

The stoving machine, or, as it is sometimes called, the sand bath, of Mr. Cumberland, which has been also used in Holland, is objectionable on account of the wet surface that it occasions the planks to have when brought round, and from its allowing particles of sand to get into the rents, by which the tools of the workmen are much injured.

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* Gallic acid is soluble in twenty-four parts of cold, and three of boiling water.—Dr. Henry.

There appears to be no good grounds for a preference of salt-water in boiling, and certainly none in steaming of plank; whilst, on the other hand, the practice is attended with many inconveniences; the charge of bringing it to the dock-yards in the River Thames * is considerable, it is attended with trouble, and the boilers (which are of copper) are much injured, and, indeed, soon destroyed by the incrustation of salt, that takes place on their bottoms; to which objections may be added, that it neither enters so freely, nor does it take off so abundantly the vegetable juices. Steam machines, on an improved principle, are used in many private ship-building yards, and are said to supple planks better than boilers.

Entrances to the holds of ships, one at the head, and another in midships, are left open as long as the state of the works will admit; not only for the conveniency of conveying the materials on board of them, but also to facilitate the seasoning of the timber by ventilation. For this purpose, also, the whole of the tree-nail holes are bored, but such tree-nails only driven, as are absolutely necessary to keep the planks in their places; by these means currents of air are made to pass freely through the centre of the timbers in every part of the ship, which, by their rapid circulation, quickly removes all superabundant moisture. A strake is left open on the outside of ships of the line opposite

* If it should be found expedient to continue the use of sea-water, it is a consideration of moment, whether factitious salt-water, would not be cheaper and better than that sent from the Nore.

to the opening above the strake on the orlop beams, to convey air to that part of the ship; and the caulking of the seams is omitted until a few weeks before the appointed time for their being launched.

It is the practice to mould the timbers of ships larger than the proper size, in order to allow, before planking commences, of their being dubbed fair to their scantling; this, however, should be done at least one month before the planks are put in their places, for by removing the exterior surface of the wood, rendered dry and hard by exposure to the air, and immediately working the planks, the effects of seasoning are, in a measure destroyed; a new surface being exposed, an exudation of moisture takes place, and the timber, however long it may have been felled, shrinks *.

All rents or cracks in the materials, arising from the action of the air, are slightly caulked, or as it is termed, chinced, to prevent water passing into the interior of the timber.

The painters' work is not performed, until it is ascertained that the materials are so far seasoned that they would be likely to suffer by its being longer omitted. In fine, every precaution is taken during the time the ships are building, to prevent water

* One example will be sufficient to prove very forcibly this assertion; when the Irresistible, of sixty-four guns, (which ship was built in the year 1787,) was taken to pieces at Chatham, Jan. 1816, it was remarked that one of the top timbers had been converted from an oak, very bright in colour, and of a very close texture, and that it was then in a sound, and apparently, dry state. A cube of three inches was cut therefrom, which weighed fifteen ounces. It was kept in a room moderately warm, and in June 1820, it weighed only eleven ounces and three quarters.

from getting between the materials, and to promote their seasoning, as much as possible, by proper ventilation.

At one period in the seventeenth century, a barbarous practice * prevailed in his Majesty's yards, of forcing water against the internal planking of ships, in their holds, in order to detect any leaks in their bottoms. This is still done in the service of the East India Company, and has been followed by some merchants; but "it is a custom more honoured in the breach than in the observance," for whatever precautions may have been taken, during the time the ships were being built, to keep the materials in a dry state, they are thus rendered useless. Leaks are discovered in his Majesty's ships by the injection of coal tar, and which, getting into rents or the interstices that may have been left between the timbers and planking, or in the fillings, becomes hard by exposure to air, and from its insolubility, prevents the introduction of water.

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* This is given upon the authority of a public document, bearing the date of 1670.

CHAPTER VII.

MEANS WHICH HAVE BEEN TRIED FOR THE PRESERVATION OF SHIPS AFTER THEY ARE BUILT.

THE preservation of ships, which are not required for immediate service, is a subject of considerable moment, and various methods have been introduced or recommended at different times, to attain this object.

The ships of war at Venice for centuries past, and those at Carlscrona, since the year 1764, have been kept until wanted on slips, or in docks, protected from the weather by roofs; at the former port, there are sixty-two docks and slips, and at the latter, seven docks roofed over, either for this purpose, or to keep them dry while being built or repaired.

At Venice many slips are in a line of continuity, and when they are not occupied by ships, they are used as storehouses, in which are placed converted timber or other naval stores that are not of a very perishable nature. In the year 1790, there were twenty-two ships of the line under roofs at this port, some of which had been in that situation for fifty-nine years; yet it was stated that their timbers and planks were perfectly sound, although very much shrunk and rent *.

* Mr. Strange's evidence before the Commissioners for Land Revenue.

This practice, of foreign countries, has induced many recommendations to the British government to pursue this method; and there appears to be no doubt that ships are better preserved thereby, than by any other modes which have been put in practice; the wear of the copper-sheathing is also saved, which is very great, and therefore expensive, on those ships that lie up in harbours. And as slips afford better means for ventilation than docks, and as they are less expensive in their formation, a preference is to be given to them for this purpose. As a proof of the advantage of keeping ships on slips, may be instanced the Royal Charlotte yacht; this vessel received a large repair which was completed in July 1784, but remained on a slip in Deptford-yard, covered over until Oct. 1797, and afterwards proved a durable vessel.

It was the practice, until the middle of the eighteenth century, to build ships either in docks or on slips as they might be vacant; but the construction of large ships in docks was then abandoned. The Victory, of 104 guns, built in Chatham-yard, and completed in 1765, was the last ship of the line constructed in a dock.

The great extent of the English navy, and the present limited means which the dock-yards afford, render it impossible to keep all the ships upon slips. The expense of obtaining greater ground space, and excavating and constructing a sufficient number of slips for the purpose, would be enormous, so that the plan is not likely to be carried to a great extent in this country. Admitting, however, the practicability of the measure, if ships, on any emergency were to be launched, it would always be

found expensive and troublesome, and sometimes impossible, to heave them up again when no longer required for the service, for which they might, at a particular moment, be wanted.

When those docks, set apart for the repair of ships, have not been vacant, frigates have been from time to time hove upon slips for repair; they are first docked to have bilgeways fitted, and heaving up is then done without much difficulty, as their absolute weight is not considerable, and the operation is rendered easy by the sliding planks being placed at an angle of only four degrees ten minutes.

In one instance a ship of the line (the Kent of 78 guns) has been taken upon a slip for repair; this was done at Plymouth in the year 1817; for the purpose, fourteen capstans were employed, each acting upon a three-fold purchase, and 2,116 men engaged in the undertaking. To render the ship as light as possible, all the internal fittings, such as cabins, bulk-heads, store-rooms, *&c.*, were taken down, and the stern, quarters and channels, amounting together to nearly 400 tons, were removed; the absolute weight of the ship, which was calculated with great nicety from the displacement, was thus reduced to 1,401 tons. The operation occupied forty minutes from the time the bilgeways were brought to the sliding planks, until the ship was placed in a proper situation on the slip; the expense of docking, fitting bilgeways, and heaving her up, amounted to upwards of 1,900*l**.

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* The repairing of a ship upon a slip, is attended with considerable difficulties, which are not experienced in a dock, the greater number of securities required to pre-

Although this experiment on the Kent, thus *reduced in weight*, was attended with success, it is to be apprehended that failures would be experienced if the system were carried to any great extent; for should the power at any time, from accidents, or other circumstances, be taken off, and the whole weight settle on the sliding planks, adhesion would be the consequence, and no force that could be then applied, would be sufficient to move the ship a-head. As a proof of this, great difficulty has been experienced in moving vessels, even in those instances when they have stopped on the slips, in the attempts to launch them down an inclined plane *.

Since it is evident that the fleet, according to its present numbers †, cannot be kept upon slips, the best methods of preserving them afloat becomes a matter of primary importance,

Ventilation by the most powerful and efficient means, particularly below the line of fluitation, and cleanliness are chiefly to

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serve the form of the body, the greater length of the shores, the additional expense of stages, and of labour in removing the defective materials; added to which, the expense of docking, heaving up, launching, and re-docking to have the cleats removed, and the bottom sheathed with copper, would increase the charge, in giving a large repair to a ship of the line, at least 5,000*l*.

* In warm climates (in Spain in particular,) where ships are taken frequently upon slips, difficulty has been found to prevent adhesion in consequence of the dry wood absorbing the warm tallow. To prevent this, they chalk the ways, and afterwards rub them hard, so as to bear a polish, before the tallow is placed thereon. This has been recently done at Plymouth, under the direction of E. Churchill, esq., the master shipwright of that yard, and found completely to answer the intended purpose.

† During the last wars, the fleet at many periods amounted to upwards of eleven hundred sail of ships and vessels of the various classes.

be attended to: when these have been neglected, the worst consequences have ensued.

A more striking example to prove this fact cannot be given, than that detailed in Pepys's *Memoirs of the State of the Navy*, published in the year 1690; and as the writer was first a commissioner of the navy, and subsequently, at two periods, secretary to the Admiralty-Board, the facts detailed are to be depended upon; and as they shew the fatal consequences of neglect in this branch of duty, they are inserted at large.

Mr. Pepys was dismissed from his office of secretary to the Admiralty, in the year 1679; at that time there were thirty sail of the line, either in the progress of being built or that had been recently launched, and which he denominates *new ships*. In the year 1684, it was discovered that the navy, the conducting of which had been intrusted to commissioners, had fallen into a great state of decay, and in May, 1684, Charles II., took the management thereof into his own hands, assisted by his brother the duke of York, (afterwards James II.,) and, as a preliminary step towards its restoration, recalled Mr. Pepys to the situation of secretary to the Admiralty-Board. A survey was held upon the fleet, but more particularly upon the thirty ships *

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* The following is a correct list of the thirty new ships alluded to in the "Memoirs," with the date of the year and place whence they were launched.

Rate.				
1	Britannia,	launched.....	1682	at Chatham.
2	Albemarle	„	1680	Harwich.
„	Coronation	„	1685	Chatham.

recently launched; when it was found, as he states, "that the greatest part nevertheless of those ships, (without having ever yet lookt out of harbour,) were let to sink into such distress, through decays contracted in their buttocks, quarters, bows, thick-stuff without board, and spirkettings upon their gundecks within, their buttock planks some of them started from their transoms, tree-

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Rate.				
2	Duke	launched	1682	at Woolwich.
„	Dutchess	„	1679	Deptford
„	Neptune	„	1683	Deptford
„	Ossory	„	1682	Portsmouth
„	Sandwich	„	1679	Harwich
„	Vanguard	„	1678	Portsmouth
„	Windsor Castle	„	1678	Woolwich
3	Anne	„	1678	Chatham
„	Berwick	„	1679	Chatham
„	Bredah	„	1679	Harwich
„	Burford	„	1679	Woolwich
„	Captain	„	1678	Woolwich
„	Eagle	„	1679	Portsmouth
„	Elizabeth	„	1679	Deptford
„	Essex	„	1679	Blackwall
„	Exeter	„	1680	Blackwall
„	Expedition	„	1679	Portsmouth
„	Grafton	„	1679	Woolwich
„	Hampton-court	„	1678	Deptford
„	Hope	„	1678	Deptford
„	Kent	„	1679	Blackwall
„	Lenox	„	1678	Deptford
„	Northumberland	„	1679	Bristol
"	Pendennis	„	1679	Chatham
„	Restauration	„	1678	Harwich
„	Stirling Castle	„	1679	Deptford
„	Suffolk	„	1680	Blackwall

nails burnt and rotted out, and planks thereby become ready to drop into the water as being, (with the neighbouring timbers,) in many places perished to powder, to the rendering them unable with safety, to admit of being breemed for fear of taking fire, and their whole sides more disguised by shot boards nailed, and plaisters of canvas pitched thereon (for hiding their defects and keeping them above water,) than has been usually seen upon the coming in of a fleet after a battle ; that several of them had been newly reported by the Navy-Board itself, to be in danger of sinking at their moorings."

The decay of the ships was imputed by the Navy-Board and officers of the yard, to the hastiness of " their building, the greenness of the stuff, and especially to the effects of the East-country plank wrought thereon." These were, however, disproved, by the time the ships had been building, the state of the store of English timber, and evidence from experience that the East-country plank is as good, if not superior, to any other for the bottoms of ships ; and the defects were attributed by the government " to the omission of the necessary and ordinary cautions used, for the preserving of new-built ships, divers of them appearing not to have been once graved, nor brought into dock since they were launched; their holds not cleared nor aired, but, for want of gratings and openings, their hatches and scuttles, suffered to heat and moulder, " till," says Mr. Pepys, " I have with my own hands, gathered toad-stools growing in the most considerable of them as big as my fists." " Port-ropes were also found wanting for airing them in dry

weather, nor were any planks removed upon the discovery of decays." Mr. Pepys further states, "that the ships were so deeply infected with the evil by which they were (even in their thick-stuff,) become rotten, and reduced to powder."

That the defects detailed in Mr. Pepys's work were not aggravated, is highly probable, for the same results have been the consequence, even of late years, when ships have been suffered to lie at their moorings in a neglected state*.

Forced ventilation, by mechanical and other means, has been frequently attempted at different periods for the preservation of ships. In the year 1665, Sir John Murray presented a paper to the Royal Society, proposing to effect this by metal pipes passing from the fire in the galley to the hold; these pipes were two inches and a half in diameter †. This notion of ventilation has been frequently recommended, and tried by repeated experiments.

In the year 1748, Mr. Sutton's mode‡ of extracting the foul

* The ships here alluded to, were some vessels fitted at Woolwich for fire-ships. Trunks, lying in a horizontal position, were placed between decks to hold the combustibles, and the method of fitting was denominated the internal principle. After lying some time in ordinary without undergoing examination between decks, (in which the trunks were fitted) their defective state was accidentally discovered by the foot of a person sinking through the upper deck of one of them. When the hatches were opened, the fire decks were literally filled with fungi, which were hanging from the upper to the lower decks in the shape of inverted cones.

† This is given on the authority of Dr. Hales, in his work on ventilation; but as Sir John Murray's paper is not printed in the *Philosophical Transactions*, it is probable that it is preserved in the archives of the Royal Society.

‡ Dr. Hales gives the invention to a Mr. Reed, and the application of the principle only to Mr. Sutton.

air by means of pipes, leading from the fire-place into the hold and lower decks, was introduced into all new ships; the pipes were of copper, two inches and a half diameter in the clear; these were not, however, found to come up to the expectations formed of them, and were discontinued in the year 1757.

Mr. Lukin, in the year 1808, renewed this principle of ventilation, and received a considerable reward from the government, for what was considered a successful application thereof in hospital ships, transports, *&c.*

There is reason, however, to believe that the modes of application hitherto made of this principle, have rendered it neither powerful nor efficacious. In some ships lying up in ordinary, fungus has been found growing near to the mouths of the pipes, which could not be the case if the draught of air were very rapid; this method of ventilating ships was tried in France about the middle of the last century, but it has been also abandoned in that country. The want of efficacy is likely to have arisen from the smallness of the tubes through which it was designed the foul air should pass, as great difficulty is always experienced in promoting a circulation of air through pipes of small diameters, from the friction that necessarily takes place; and it is to this, or the insufficiency of the machines employed, and not to the inaccuracy of the principle, that the failures are to be attributed.

Wind-sails, which were invented by a Dane *, and first used

* This is stated by M. Du Hamel in his work "*Moyens de Conserver la Santé aux Equipages des Vaisseaux,*" but the date of the invention is not given. Wind-sails were,

in Danish ships, were introduced generally into the British navy in the year 1740, and are now used by all the European powers; they are very useful in ships which are crowded with men, horses, or other animals; or when they are laden with cargoes that are liable to heat, and undergo decomposition; for whenever there is wind, fresh air passes down them in abundance, and at all times the lighter air, rendered unfit for respiration, ascends through them, and its place is supplied by that of the atmosphere. But in ships lying up in ordinary, it appears to be doubtful, whether all the advantages are derived that are expected; in calms, they are of little if any service, and even when there is a breeze, care is required to trim them to the wind*, or they will not act, and in damp weather they are likely to be prejudicial.

Pneumatic machines have also been used in ships to promote ventilation: bellows appear to have been first applied in Sweden for this purpose, and they were so contrived, as to draw at pleasure the foul air from the holds or lower decks of ships, or to force atmospheric air into them.

Dr. Hales, in the year 1741, made an alteration in these machines, to render their action more powerful and their

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however, partially used in the British navy, prior to the year 1699, for they are mentioned in an official document bearing that date.

* A mode has been lately introduced of fitting wind-sails with moveable hoods, having an aperture on one side; these being suspended by their centre on a frame, are easily trimmed, and when let down, form a cap scuttle to prevent the introduction of water or damp air into the ships.

application easier; indeed, his ventilators, which were generally introduced into the navy in the year 1756, differ so much from the bellows commonly in use, that they may be considered as a separate invention. The ventilators of Dr. Hales, were of large and small sizes; the former were used to draw the air from the main hold, the latter from the storerooms; the dimensions of the large machines were ten feet long, four feet six inches broad, and two feet deep; the small ones, four feet long, one foot four inches broad, and one foot one inch deep; these were fitted on the orlop deck, and a trunk, one foot square, passed thence through the several decks above, and discharged the foul air on the forecastle. Two men were required to work the large, and one the small, ventilator; their labour was first employed on the orlop, but great inconvenience being experienced on that deck from the want of air and light, this arrangement was altered by introducing a rod or spear through the decks to communicate the motion, which enabled the men to work the machines upon the middle decks of three-decked ships, and on the upper deck, under the forecastle, in those of two. There were six or eight sets of ventilators in ships of the first class, and a proportionate number in smaller vessels.

In ships in commission, the ventilators were found to be a great incumbrance on the orlop deck; and in those lying up in ordinary, they were seldom used on account of the few ship-keepers employed. To obviate this in the latter case, the Doctor recommended that they should be worked by wind-mills, which was finally carried into practice.

The inconveniences experienced were, that as leather was employed to give action to the midriffs, the rats which are usually numerous on board ships, ate through it and destroyed the capability of the machines; they were, therefore, virtually discontinued about the year 1775, the commencement of war with the Americans, but not nominally so, until the year 1794, at which time moveable machines for the same purpose, introduced by a Mr. White, and called by him extractors, were ordered to be supplied to all ships instead of the ventilators. These were nothing more than large bellows, worked by a lever, with a trunk to lead into the hold or storerooms, to extract the foul air which was carried off through a pipe on the top; means were also provided to pump in fresh air, which was conveyed to any part of a vessel through canvass hoses. These machines being subject to the same accidents as the ventilators, and as the captains of ships seldom used them, their supply was discontinued in the year 1815.

In the year 1780, small stoves, called Brodie's airing stoves, were first tried in the navy; and, in 1783, they were generally introduced for the purpose of ventilating and drying the holds and between decks of ships, both in ordinary, and in commission. Ships of the line were usually supplied with four of these stoves, and there is no doubt but that great benefit has been derived from their use.

In the year 1809, stoves were placed in the holds and on the orlop decks of some new line of battle-ships, at the recommendation and under the inspection of Mr. Lukin, with the view of

rarefying the air to a considerable degree, and carrying off the moisture that would then exude from the timber, but they were discontinued in the year 1812. As the probable effects that arose from the use of these stoves will be fully treated of in the next chapter, it will be unnecessary to notice them further in this place.

The fitting and opening of ships for a state of ordinary, have always been considered matters of much importance, and in consequence, have been more or less attended to at different periods, according to the ability and activity of the ruling authorities. To give an account of the removal of particular cabins, at one time, or this or that bulkhead at others, would only swell this work without adding to its information; suffice it then to say, that all the methods practised at different periods, were collected and revised after the American war (1783,) and general directions then given for the preservation of the fleet, from which the best effects were derived; and these are the foundation of the present practice, an account of which is about to be given. But as slight deviations must necessarily be made according to the different classes of ships, and their modes of construction, it is intended to confine the observations to a seventy-four gun ship, built according to Sir Robert Seppings's plan, and more particularly so, as all British ships of war are now constructed thereby.

To promote a circulation of air in the hold, the limber boards that come within the magazine, the fish, and spirit rooms, are taken up, the scuttles in the bulkheads unhung, and the flooring

and lining of the lightrooms taken out. On the orlop, the doors of all the store-rooms are either unhung or constantly kept open, and the upper board of each of the bulkheads to the store-rooms, is taken down. On the lower deck, the shot-racks are removed, the scuppers taken out, and two strakes of the flat of the deck, on each side, taken up. On the upper deck, the shot-racks are removed, and a trunk passing through the hole for the bowsprit, is made to communicate air to the hold, by taking up some of the planks of the gun and orlop decks. The gun-carriages of the ships of the line, in good condition, are housed in midships of their respective ships; in those of three decks, they are placed on the lower and middle decks; in two-decked ships, on their gun-decks; these are frequently moved for the purpose of cleansing the ships, and to prevent injury to the decks by the trucks remaining too long in one position. The different articles, such as water-casks, barrels, *&c.*, are put on skids, sufficiently high for a broom to pass under them to clear away any dirt that may be collected.

Without board, the boomkins, bolsters to the hawse, fillings between the cheeks, washboards under the cheeks, linings for anchors, bill-boards, bolsters for anchors, channel rails, steps to the side, chess-trees, quarter davits and portlids, are removed and stowed away in the ships; the latter are substituted by shutters, hung by their centres on pivots. At those ports where it can be done with safety, a strake is removed, extending all fore and aft, below the main wales on each side, to convey air into the ships, which openings have louver-boards fitted over them to prevent rain

or snow from passing into the frame; in those harbours or roadsteads where this cannot be done on account of the high waves which occasionally run in them, treenails are driven out in the bows, sides and buttocks, for the like purpose. The opening of ships without board, has been frequently recommended; was partially introduced in the year 1771, but only practised generally since 1814: but the policy thereof is questionable, as it is considered that at times, the air thus conveyed in abundance into the ships, is loaded with water almost to saturation, which is condensed upon the timbers, and thus causes great dampness, the forerunner of decay.

The lower masts, (with the exception of the bowsprit which is unshipped and placed on the upper deck,) are generally kept in the ships, hoods being fitted over their heads to protect them from the weather, To prevent injury to the masts by their taking up water by capillary attraction, and to afford the opportunity at all times of examining their heels and tenons, they are raised out of their steps* and lowered on pigs of iron ballast, placed on the steps over the mortises.

The use of awnings has been discontinued, and, as a substi-

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* Sir R. Seppings has lately invented a machine for the purpose of lifting the masts of ships. Two scores are cut in the heels of the masts, in which are placed two metal bars; chains which are let down from the middle, or upper decks of ships are attached to those bars, their upper ends being fixed by a rod to two other bars, in which four screws act; these are turned by levers, and are of such power, that four boys lifted the main mast of a first-rate ship in fifteen minutes. The same machine is used for lowering the masts into their mortises, when the ships are required for service.

tute, the decks exposed to the weather are painted* with white lead, which has been found sufficient to answer the purpose of preventing any injury to them from the influence of the sun. A housing is placed in midships of all ships, under which the bowsprit, top-masts, yards and other spars are stowed; this housing of boards is covered sometimes with canvass, and sometimes with paper, but in either case it is paid over with warm mineral tar; there are, however, a few ships which have a housing extending all fore and aft.

As a proof of the durability of ships when housed over afloat, the instance of the yacht which was launched from Deptford yard in August 1785, and then presented to the Prince Royal of Denmark, may be given. This vessel, while in the possession of the Danes, was so housed over, and was returned to this country in the year 1807, but not being wanted, was ordered to be taken to pieces; on being opened for that purpose, in the year 1818, she was found to be so sound, that she was sold, and is now employed in the merchants' service.

Two small airing stoves are put on board each ship, but that they shall not be used to excess, only ten bushels of cinders are allowed *per annum*.

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* Putty, composed of four parts of whiting, and one of red-lead ground in oil, was proposed by Mr. Coulson, master-painter of Plymouth-yard, as a substitute for pitch in the seams of such ships' decks as were painted; this was tried at all the dock-yards, but it was not found to answer. The decks and putty both shrinking by heat, the rain-water insinuated itself, by which the caulking was destroyed. Putty was formerly used in the seams of the quarters of ships, but this practice was discontinued in the year 1781.

To prevent the ships from arching, (or in other words, hogging,) the proper proportion of iron ballast for sea service is stowed on board; and upon that, the iron tanks filled with water, with such an addition of iron ballast * placed in other parts of the ships, as shall bring them to the draught of water required. And in order to take off the weight from the bows, several ships are moored † from their third ports from forward; this was done at the recommendation of Mr. Hookey, an assistant to the master shipwright of Woolwich yard.

The ships that are in good condition, lie singly at swinging moorings; those which require repair are generally placed where there is not a great depth of water, and are usually moored by the head and stern, and in some cases, two are placed abreast. In order to preserve these ships, they are frequently shifted; to effect which, without much trouble or expense, Sir R. Seppings has applied a collar of iron, which is put over one of the riding bitts; to this collar are fastened a few links of chain, and to them a hook. On the side of one of these links is placed a moveable ring, which by sliding over the end of the hook, prevents its being disengaged from the chain bridle

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* The French, in the year 1786, by an *ordonnance de la marine*, directed that the use of shingle ballast, should be discontinued in their Navy; but it was not until 1815, that directions were given that it should not be put into British ships of war.

† Chain moorings were recommended to be introduced into the English service by Sir Cloudesley Shovel, in the year 1690. The employment of chains for moorings, or as cables for ships, is of an ancient date; the Romans used them (made, probably, of brass) for securing their galleys.

attached to it, and thus secures a sufficient connexion between the latter and the vessel, which connexion, however, may be immediately destroyed by driving, with a few blows of a hammer, the ring from the hook.

This plan is productive, not only of considerable saving in time and manual labour when the ships are required to be moved, but also of half the chain which was formerly used, when it was applied as bridles for mooring * ships. Hempen bridles, which were an endless expense to the country, from the wear to which they were subject, are now nearly discontinued in the Navy.

The ships are frequently pumped to clear them of bilge-water, and cleanliness in every respect, is attended to; the lower decks are rubbed with dry stones, commonly called holy-stones, and with sand, the use of water † upon them being strictly forbidden.

Great care is taken to stop by caulking ‡ all leaks as soon as

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* Several ships are moored by using their chain cables as bridles. The invention of chain cables, England owes to the ingenuity of Captain Samuel Brown, R.N., and the dependence placed upon them, is attributable to the proving machine introduced by him; the application of a stay in the middle of each link for the purposes of preventing collapsion and kinking, as well as adding to strength, is also his introduction; indeed the almost universal use of chains as cables, is due to the indefatigable industry which he applied in combating objections which arise to every new plan, and in making experiments to bring their manufacture to its present maturity.

† The practice of throwing water by means of scoops, against the sides of ships every evening in the summer months, when the sun's rays had been powerful during the day prevailed for many years, in order, as it was termed, to cool them; this, however, has been very properly abandoned.

‡ The caulking of his Majesty's ships is now performed with oakum spun into

they appear; and painting for the preservation of the materials is strictly attended to, the colours used are either white or yellow, the use of black having been discontinued, in consequence of the injury that the plank suffered from the absorption and radiation of the sun's rays when that paint has been put upon the sides of ships *.

To ensure regularity of conduct in the people employed, as well as uniformity in the modes of airing, ventilating, *&c.*, the care of the ships and superintendence of the warrant officers and ship-keepers, are not only confided to the commissioners and officers of the dock-yards, but superintended also by captains and lieutenants in the Navy. The fires in all the ships are lighted, the windsails hoisted or lowered, and the temporary port-lids opened or shut by signal.

Such are the measures that are taken for the preservation of the fleet, while in a state of ordinary, and from which there is no

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threads or yarns. For many years the hair of cows and goats was spun, and in general two threads thereof used in caulking ships' wales and bottoms; this was practised in consequence of the incorruptibility of animal hair; the practice was discontinued in the year 1791, from the great difficulty experienced in obtaining supplies, and yarn spun from black oakum was substituted.

* In consequence of the injury done to ships by the absorption and radiation of heat from black, the ancient practice of painting ships with it on the death of the king, or admiral of the fleet, has been discontinued. Many instances might be adduced to prove the injury which the masts, yards, *&c.*, of ships have suffered, when employed in warm climates, from having been blackened with paint or varnish; one however, may suffice. A frigate, employed on the East India station, had when she sailed from England, her masts, yards, *&c.*, painted white, and on her return five years afterwards, brought them home; while some other ships, employed on the same station, that had had them blackened, were supplied with three sets during that period.

doubt the durability of the ships is increased. It has been an invariable practice not to put into commission new ships, if their services could be dispensed with; nor to send those to warm climates which had been recently built or repaired. Necessity, however, has frequently compelled the government to break through these wholesome regulations. Dr. Lind, in his excellent work on *preserving the Health of Seamen*, attributes many diseases and particularly fevers, to "the vapour constantly exhaling from the freshness of a ship's timbers," and deprecates the sending "new-built men-of-war on long and sickly voyages." He states that the diseases under which they then labour, resemble those to which persons are subject, who reside in low situations, and are constantly inhaling the miasm arising from marshy ground. Sir Gilbert Blane has stated that "dryness is deservedly held to be a matter of primary consideration, as well to health and comfort as to the preservation of all the valuable articles of victualling, clothes, utensils and arms*." If further evidence be required of the benefits derived from keeping and properly ventilating ships in a state of ordinary, before they are sent to sea, the durability of those which were launched shortly after the termination of the first American war, and which were not employed until the year 1793, may be cited. Without entering into particulars, suffice it to say, that independently of the period they laid in ordinary, their time of service was more than double that of the

* See Sir Gilbert Blane's treatise on the *Health of the Navy*, in which he forcibly proves the benefits that have been, and will be derived from the dry state of those ships built on Sir R. Seppings's plan, with solid bottoms.

ships which were launched and immediately commissioned during the late wars.

When ships are put into commission, no absolute rules are laid down for their preservation; the care of the ships and the health of their crews being left to the judgment of the captain and other officers; hence so many different practices to attain these objects. Much, however, has been done within the last thirty years in bringing about changes in the fitting of ships, to contribute to the comfort and improve the health of their crews. Ventilation being an object of primary importance, the bulkheads are fitted with balusters or with lattice-work, and scuttles cut in their sides. The introduction of illuminators in those scuttles and in the decks, has in a great measure, prevented the necessity of burning candles, which, during the day, consumed the vital parts of the air: the use of iron tanks * has preserved the purity of the water, and the discontinuance of shingle ballast removed the unpleasant effluvia, that frequently arose from animal and vegetable substances in a state of decomposition, which were sometimes lodged therein, or other putrescent matter that was absorbed.

The purity of air between decks, is a matter of primary im-

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* The tanks are made of sheets of wrought iron, and are in form cubes of four feet. When they were introduced a considerable prejudice was excited against them, from the erroneous supposition, that the oxide of iron would enter into the water by solution and be injurious to health. Some water that had been in a tank for five years, was lately examined; it was in a good state, and on being subjected to a chemical test (tincture of galls,) the presence of iron could not be detected, the water after the solution being limpid.

portance to health; officers must frequently have observed that ulcers of the most alarming kind, and scorbutic complaints, that appeared to baffle medical skill, have been frequently cured by forced ventilation, and perhaps there is no better mode to effect this, than by airing stoves. There are many instances of the progress of fevers having been stopped, in warm climates, by the removal of the fire-hearths in frigates, from the upper to their lower decks. All unnecessary cabins *, or bulkheads, which tend to prevent a free circulation of air, should be removed. Cleanliness is particularly to be attended to; but to effect this, water should be used only in those situations where it will be quickly taken off by evaporation; dry-rubbing between deck has, therefore, a decided preference to washing. The ships should be frequently pumped, as the agitation of water creates ventilation in their holds, and for the purpose, water fresh from the sea should be let into their wells: the powerful effluvia from bilge-water, is seen from articles of metal, particularly those of silver, being so soon tarnished thereby. Particular attention should be paid to keep the shelf-pieces clear of oakum, rags, or any other articles that will stop a circulation of air, or get in and rot between the frame timbers. In fine, it should at all times be remembered, that whatever contributes to the preservation of the ships, tends also to ensure the health of their crews.

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* "Albeit the marriners doe covet store of cabbins, yet indeed they are but sluttish dens, that breed sicknesse in peace, serving to cover stealths, and in fight are dangerous, to tear men with their splinters."—Sir Walter Raleigh's *Essay on Shipping*.

The caulking in the seams of ships should always be kept in a hard and sound state; this not only contributes to dryness, and, therefore, to the preservation of the materials, but it also adds very much to their strength. Many ships have been destroyed by a neglect of this important duty, particularly when they have been employed in warm climates, and probably from the notion, that the caulkers injure the appearance of the paint work: although cleanliness and neatness are much to be commended, yet there are paramount duties; it should always be considered, that a ship of war is designed for service, not show; and the stronger and sounder the hull, the more efficient will she be at sea or in battle.

CHAPTER VIII.

THE NATURE, CURE, AND PREVENTION OF THE DRY-ROT.

THE term dry-rot, as applied to defects in the ships of the Royal Navy, is a late introduction, for in no official document of an earlier date than the year 1808, is that name to be found; hence there is a general opinion, that it is a disease of recent occurrence, and not, what is the fact, that it has existed in all times, and that the name alone is new. To prove that it has been found in houses, as far back as history will carry us, it will be only necessary to advert to the Holy Scriptures *, in which it is too well described to be mistaken, under the denomination of "the plague or leprosy in the house †." And in reference to ships, we shall find that in the year 1684, all those of the line which had been recently launched, were affected with the dry-rot, for Mr. Pepys declares, "that he gathered toad-stools from out of their holds as big as his fists;" but as the state of these ships has been so fully detailed in the seventh

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* Leviticus, Chapter 14.

† Dr. Mead, in his *Medica Sacra*, considers that the appearances of greenish and reddish streaks, as mentioned in the Bible, to be the effects of the fermentation of the materials of which the houses were built.

chapter, it will be unnecessary again to enter into particulars. If proof be necessary, from a recent instance, that the dry-rot has existed without the name being applied, that of the Foudroyant of eighty guns may be given: this ship, although launched so recently as the year 1798, was found, in 1802, to be in such a defective state as to require what is termed a middling repair, or in other words, to be nearly rebuilt; and these defects proceeded from, or were accompanied by, a considerable quantity of fungus; yet, no mention is made in any of the reports of *dry-rot*; from which it may be inferred that the appearance in this ship was common to many, and therefore did not require particular comment. Having thus proved that the dry-rot has existed in ships for a long period of time, although the name was not in common use until within the last ten or twelve years, it remains to be mentioned, that since the defective state of the Queen Charlotte of 100 guns was discovered in 1811, and this term applied to her defects, it has become a favourite name, and been given indiscriminately to almost every description of rot, whether fungus was or was not present. By the terms being thus confounded, the cause of the decay of ships cannot be accurately ascertained from official reports, but only by actual inspection. That no error may occur from these means in reasoning upon this subject, and in order to form an inseparable connexion between the name and the thing signified, it is right to premise, that whenever dry-rot is mentioned, it is to be understood only to mean the decomposition of timber, either caused by, or accompanied with, the presence of fungus.

It would be useless to enter upon, in order to refute, all the

fanciful theories of authors, who, in the darker ages of science, have attempted to account for the growth of fungi, by supposing that they proceeded from the putrefaction of vegetables; or to combat the later opinions of others, who have reasoned upon the same data, and have thus renewed, while they have attempted by words to deny, a belief in the notion of equivocal or spontaneous generation *; erroneously supposing that these plants arise from a modification of the juices, or the vital principle, of others, which by being prevented from obeying the laws of nature, in the production of buds and leaves, assume the form of fungi.

To merely notice that, in a less advanced state of the knowledge of vegetation, fungi have been considered by some naturalists to belong to the animal †, and by others to the mineral kingdom, is all such dreams require or deserve; but later discoveries and inquiries, whilst they have restored to these productions their vegetable origin, have established laws that regulate their propagation, and have given to each species its peculiar nutriment and characteristic habits.

Fungi being proved to belong to the vegetable kingdom, and innumerable, but very minute, seeds having been discovered in

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* The Egyptians introduced the notion of equivocal generation, to account for the swarms of flies which were bred every year in the mud deposited by the overflowing of the Nile, after the water had subsided.

† This notion arose from the larvæ of insects, and insects themselves, having been found in fungi, particularly when they are in a state of decay. And also as they afford ammonia by distillation. And it was long doubted whether this was found in any but animal substances.

most of them, for the purpose of their propagation, they are placed in the class cryptogamia, or among those vegetables, the fructification of which is concealed; but supposing that the presence of seed had not been detected, there would be every reason to believe from analogy, that they are dependent upon nearly the same laws as other vegetables; that they are produced either by germs, or seeds, or by both; and whether the seeds are taken up by the sap of the trees, and deposited in the sap vessels; or whether they are so abundant as to be spread over the whole face of nature, is not necessary to the argument: suffice it to say, that whenever a proper *nidus* is formed, germination and fructification generally follow.

When an animal or vegetable body is deprived of life, it no longer belongs to the class of beings which maintain a rank in the economy of nature; the very principles which were the causes of its nutriment, then become the means of its decay; and for the purpose, fermentation, the forerunner of putrefaction and decomposition, is the agent. "The aim of nature in exciting fermentation," says Fourcroy, "is manifestly to render more simple, the compounds formed by vegetation and animalization, and to employ them in new combinations of different kinds." Thus the beautiful harmony which all admire is preserved, and the great law of nature, that the death of one body shall give life to others, fulfilled. When the animal dies, and fermentation takes place, flies deposit their eggs, maggots are formed, and the fleshy parts destroyed. When the vegetable body falls, it is eaten by worms of a different kind, or destroyed by fungi;

and if in consequence of the employment of art the duration of either is extended, "that slow, but sure destroyer, Time," at length renders them to their native earth, to serve in their turn for nutriment to other vegetables, designed for the nourishment or convenience of the animal kingdom.

To bring about decomposition, the same agents are necessary as to promote vegetation,—air, heat, and moisture, under proper combinations and modifications; the latter, however, is the most efficient cause: the temperature must be above thirty-two degrees, but not raised higher than ninety-six degrees of Fahrenheit. In a vegetable body, when the fermentative process begins, the vessels or fibres of which it is composed are put in motion, a separation of them takes place, its volume is in consequence enlarged, and it generally suffers an alteration in colour: as the process proceeds towards putrefaction, heat is evolved, and carbonic acid gas disengaged. The proper compost for fungi being either decomposed vegetable substances, or such as are in a state towards decomposition, their growth is rendered luxuriant by the heat, and also by the presence of the carbonic acid gas; for it has been found by experiments*, that eight or ten hundredths of this gas, added to the air of the atmosphere, is favourable to the growth of all cryptogamous plants: such is the condition of the air in the grotto *del Cano*, and in other subterraneous situations in which they abound. It is from these combined causes, that buildings composed of wood are so soon

* M. Humboldt's.

destroyed after the fermentative process has begun; and it is highly probable, that the gas which is given out of a piece of timber in a state of decomposition, may affect (as is the case in the vinous fermentation,) all the rest in the building; the fungi then shoot forth, adhere to the timber over which they pass, and for their support, deprive it of the moisture which holds the vessels together; it becomes at first dry, at length friable, and from these effects proceeds the term dry-rot.

To shew that in most cases when vegetable substances are decomposed, fungi exist, it will be only necessary to cite some practical instances, which must have come under the observation of every one. The number found in the autumn of the year, under evergreen trees, particularly those of the *pinus* class; these trees are constantly shedding leaves during the summer, which are decomposed before autumn, and the result is a plentiful crop of fungi. The *agaricus quercinus* is found on the oak-tree only, where the timber has been decomposed; it is seen where a branch has been taken off by design or by accident, and the wood rendered rotten by rain-water*. Fungi which

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* "There is also another unperfect plant, that (in shew) is like a great mushrome. And it is sometimes as broad as ones hat, which they call a toads-stoole: but it is not esculent; and it groweth (commonly) by a dead stub of a tree; and likewise about the roots of rotten trees: and, therefore, seemeth to take his juice from wood putrefied; which sheweth by the way, that wood putrefied yeeldeth a frank moisture."

BACON'S *Sylva Sylvarum, Cent.* 6., *No.* 551.

Again—"Mushromes are reported to grow, as well upon the bodies of trees as upon their roots, or upon the earth: and especially upon the oak. The cause is, for the strong trees, are towards such excressences, in the nature of earth, and, therefore, put forth mosse, mushromes and the like."—*Cent.* 7. *No.* 640.

grow upon timber kept in piles, are found generally in autumn, after the summer's sun and autumnal rains have decomposed the timber; they are gathered usually from the soft spongy sap-wood, which from its absorbing water is the first to suffer decomposition, but they are seldom to be met with growing upon the heart of the timber.

Fungi in ships, are usually found between the outside and inside lining, where there has been much of moisture with confined air, and they not only vary in appearance, but also in the mischief which they create. While the *Xylostroma giganteum*, a fungus which resembles *chamois* leather, is generally confined to the rotten wood which produced it, the *Boletus lachrymans* spreads with a wonderful rapidity, and by taking root on the timber, or insinuating itself into the fissures, like a parasite, soon destroys the parent by which it was produced and is nourished.

Fungi appear to be of a very corrosive nature, for the surface of lignum vitæ, teak, and other hard and generally durable woods, have been destroyed by being placed in contact with timber on which they were growing; the harder and closer the vessels, however, the slower progress these descriptions of plants make in destroying the timber.

The presence of dry-rot may be often detected by the fetid ammoniacal smell, which is always observed in the ships in which it exists to any extent.

Having proved that the primary cause of dry-rot is the fermentation and decomposition of vegetable substances, it of

course follows, that if means be taken that will prevent these, a preventive and cure are necessarily effected; but as such as have been tried that were calculated to prolong the durability of timber, are detailed in the fourth chapter, a repetition will not be necessary; our attention will, therefore, be confined to such as have been carried into effect, to accomplish only the cure of the dry-rot.

As a practical instance will illustrate better the nature of the dry-rot, than any theoretic opinion, however plausibly given; a detail of the defects in his Majesty's ship, Queen Charlotte, of 100 guns, together with an account of the measures which were practised to prevent a recurrence of the evil, after the repairs of that ship were completed, will no doubt, be acceptable. The case of the Queen Charlotte has been selected, because the extent of the mischief was great, the appearances the same in this, as in all the other ships so affected, as it is the only instance, in which a scientific examination took place of the several kinds and descriptions of the fungi*, and also as all the accounts which have before appeared, have been garbled to suit some particular hypothesis, or have been given in complete ignorance of the facts.

The keel of the Queen Charlotte was laid in October 1805, the frame completed in December 1806, and it stood to season

* It was at the recommendation of the author, that that eminent botanist, Mr. Sowerby, than whom no one is better acquainted with the habits of fungi, was employed; and it is from his, Mr. Lukin's, and the dock-yard officers' reports, as well as a personal inspection, that the account is given.

until September 1808, when the wales were worked, and the operation of building continued until May 1810, on the 17th of which month the ship was launched; in the latter end of 1809, and in the beginning of 1810, stoves were placed in the main hold, magazine, bread, and store-rooms, and also on the orlop deck; and in order to dissipate the moisture quickly, the hatches were covered over, and the heat raised to about 120°. This mode of airing ships was recommended by, and practised under the direction of, Mr. Lukin. In August 1810, she was transported to Chatham to be coppered and fitted for a state of ordinary; and in October following, was sent to Sheerness to be laid up at that port. In May 1811, she was navigated to Plymouth, and in July of that year, the officers discovered, when the artificers were caulking the topsides, that "the plank was in a state of rapid decay:" thus in the short period of fourteen months from her having been launched, a first-rate ship of war, without having been in commission, was so defective as to require all the planking both within and without board, together with many of the timbers and beams to be removed, and shifted, from the topside to the gun-deck clamps; but it is worthy of remark, that below this situation there was no appearance whatever of fungi. The defects were ascribed to the great quantities of Canada oak, and American pitch-pine timber which had been worked in the ship; woods, particularly the former, subject to be soon decomposed. Although the fact that these woods are subject to early decay cannot be disproved, yet it appears, that it was much accelerated by the works

having been commenced and carried on at improper seasons of the year.

The Queen Charlotte was built exposed to the weather; the working of the wales and outer planking was begun in September 1808, by which the rain-water that usually falls in abundance at this season of the year, was enclosed between the frame timbers and planking; and it is to be observed, that the caulking of this ship was also performed in the winter months, for it commenced in January, and was completed by the end of February 1810, thus again confining the rain-water which must have insinuated itself into the ship through the seams. The damp air and water so confined, acting upon wood soft in texture, naturally decomposed it, produced a proper nidus, and the growth of fungi was the consequence; and although many of the timbers of the frame, composed of hard English oak, were injured, yet they were by no means affected to the extent of those woods which were of the produce of America.

Mr. Sowerby found on examining the timber of the Queen Charlotte, the following fungi; *Boletus hybridus—Boletus medulla panis—Xylostroma giganteum—Auricularia pulverulenta,* and the *Boletus lachrymans**.

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* The fungi enumerated above, are thus described by Mr. Sowerby, in his elegant work on English fungi:

Boletus hybridus.—This *boletus* has many characters in common with the *boletus lachrymans,* and *boletus medulla panis.* It is generally found growing horizontally under rotten floors, attached by its back, spreading in large patches, forming more or less broad ramifications often inosculating, of a cottony substance like the above-

The following are the measures which were taken to prevent a recurrence of the evil. After the ship had been stripped, to a certain degree, to ascertain the nature and extent of the defects; an awning was raised to prevent rain-water from falling upon the frame; every thing removed that prevented a free circulation of air, and all the materials to be used in the repair, were kept as

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mentioned, which are commonly known by the name of dry-rot. The pores which are seldom seen, are long, tubular, and cylindrical, by which it is distinguished from the other two.

Boletus medulla panis.—Sometimes an inhabitant of dark cellars on very rotten wood, or of the shady parts of damp woods. In addition to its general character of looking like the crumb of bread, or the inside of a loaf, we may remark, that in its latter or brown state, mouldering or rotting away, it resembles the raspings of bread. It frequently branches to a considerable length, the broader parts more or less producing pores, which are irregular with rugged divisions. The whole plant is perfectly white, except in decay, when the pores become of a yellowish brown; the texture is of a fine cottony nature.

Xylostroma giganteum.—This may be truly named *giganteum*, from the gigantic strides it takes through some of our largest oaks. It appears to be composed of minute branched fibres, which are less compact internally, with little versicular-like substances, somewhat egg-shaped, resting by their broadest bases on the ends and other parts of the branches. The narrow end seems somewhat opaque, as if it were an *operculum*. There is also scattered dust of a brownish cast, copious among the rotten remains of the wood, giving it the appearance of Scotch snuff. It should seem that this fungus may have given rise to the use of the *Agaricus Chirurgorum* and *Agaricus querneus*, as Ray says, it was used by the country people of Ireland to cure wounds; and thus I think the true styptic agaric should be *Agaricus querneus*, and not *Boletus formentarius*, which nearly resembles it, sometimes does. It seems the oak agaric is most strongly recommended. *Agaricus quercinus*, nearest resembles the oak leather in delicate fibrous texture, and may be readily cut into slices and freed from impurities; the other two are of a less delicate colour, and require more preparation.

I have specimens of a part of a poplar affected with a fungus, something like the above, which penetrates the tree more thoroughly as it were taking place of the wood: but in this I have discovered nothing like fructification.

Auricularia

dry as possible ; the planks on which fungus had grown, but which were not much injured thereby, were dubbed over and replaced ; the frame timbers which were affected, but not so much so as to be rendered useless, were scraped, and where necessary, the defects chiselled out, and graving pieces put in. Such planking brought on as was not considered to be well-seasoned, was previously charred on its inner surface. To dissipate the moisture which had fallen into the ship, before the awning was put up *, stoves were used, and the temperature raised to ninety degrees ; these, while they accomplished this object, speedily

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Auricularia pulverulenta.—First found by the Rev. Mr. Watts on the whitened fir-beams in the wall of an outhouse at Ashill, Norfolk, in Dec. 1798. Mr. D. Turner has since communicated some from Yarmouth, found in a similar situation. The substance is like the dry-rot or *boletus lachrymans.* It protrudes umbilically in concentric circles, emitting a snuff-coloured powder, nearly with the same regularity. The upper edges of the back, detaching themselves from the wall and hanging over, forms the top.

Boletus lachrymans.—Much too common in England, taking possession even of the bond timbers in houses, and often attached by the back under stair-cases, *&c.* (The best way to guard against this evil, is to introduce a free circulation of fresh air, and to avoid building in damp situations.) In damp places, the fructification is very frequent, and has often an extremely elegant grotesque appearance, hanging in inverted cones and other shapes. The porous surface is very unequal, forming various reticulations and sinuses. Their colour varies from yellow to orange, or a bright red brown. The whole fructification often forms a circle from one to six or eight inches in diameter, surrounded with an outer substance, tender and pithy or cottony, of a pale brown. The upper part is commonly clothed with a white mucor. This pithy substance, without fructification, is often found by itself and is very dry; whence the English name of dry-rot. Yet as the fructification is seldom without drops of water resembling tears, the Latin name *lachrymans*, or weeping, has been given.

* An hygrometer was placed in the hold near the pump well, by Mr. Sowerby ; it stood there at 826.6°, outside the ship at only 464.2°, perfect wetness being indicated on the instrument by 1000°.

checked the growth of fungi. Pulverized mundic, in the form of mortar, was put upon some of the timbers, but this was not carried to any extent, on account of the injury that some of the workmen experienced from its being taken into their systems by the absorbent vessels; and means were provided to throw the fumes of this marcasite, when in a state of vapour, into the openings of the frame of the ship. The repairs of the Queen Charlotte were completed in 1812, and the ship then put into commission. To prove that these means completely answered the purpose, it will be only necessary to state, that on a recent examination of the ship, (in 1820) there was no appearance of fungus: she is now serving as a guard-ship at Portsmouth.

Caloric, or heat, has been considered as the exciting cause of the dry-rot; there is no doubt but a proper modification of this principle is not only necessary, in order that vegetation may flourish, but also requisite to carry on and increase the putrefactive process. The heat that favours these, may be considered to be between 45° and 90° of Fahrenheit; below the former, vegetation is languid, or is altogether prevented; and at a heat above the latter, it soon withers and dies. Perhaps, there is no better process for the preservation of animal, or vegetable substances, than exposing them for a time to a considerable degree of artificial heat; with this view, stoves were placed in the Queen Charlotte, and the temperature in the hold, and on the orlop deck, raised to 120°; and it has been shewn, that in those situations the timber was sound, and there was no appearance of fungus. The stoves in question were put into

the ship during the winter months; the heat rarefied the internal air, increased its capacity to hold moisture, and this, in ascending through the openings between the timbers, in its way upward, meeting with air and wood of a much lower degree of temperature, was condensed upon the frame, and deposited its moisture*, which, acting upon the vessels of the timber, decomposed them; and from this circumstance is the dry-rot, which was found only above the orlop-deck, to be attributed. The use of the stoves in question was discontinued in the year 1812, in consequence of the recommendation of Mr. Sowerby to that effect.

Airing stoves, however, should always be used in ships, particularly those laid up in ordinary, not for the purpose of raising the heat to a considerable degree above that of the atmosphere, but to keep an equilibrium of temperature both within and without side the ship; the advantages arising from these stoves were evident in the fleet laid up shortly after the

* The moisture arising from the condensation of the air, from a difference in temperature, may be witnessed in the magazines of ships. Although every precaution has been taken to keep them dry by linings, and passages having several doors to prevent a sudden ingress of warmer air, and also placing absorbent substances, (such as pulverized charcoal, or mats which had been for some time steeped in salt-water, having therein as much of the muriate of soda, as it would hold in solution, and these afterwards well dried,) under the flooring or in the rooms themselves, yet much powder was injured by moisture, when kept in wooden barrels. Mr. Professor Leslie proposed the most absorbent substances to prevent this, *viz.*, sulphuric acid, to be put in metallic boxes under the flooring, or muriate of lime placed at the top and bottom of the magazines, but these preventives are now rendered nearly nugatory, by the powder being kept, as recommended by Dr. Franklin, and introduced by General Sir Wm. Congreve, in wooden barrels, lined with thin metal sheets.

first war with America, than which no ships have been more durable. There is no mode of ventilation so powerful and efficient as that brought about by the agency of fire, particularly in situations where ventilation by other means is difficult; and by drying up or carrying off the moisture by a rapid draught of air, as fast as it condenses or exudes, the growth of fungi is prevented.

The decay of such ships as are employed in the East and West India trades, that bring cargoes of pepper or cotton to this country, has been cited as instances to prove, that in them, heat is the cause of the dry-rot; their cargoes having in some instances been found in such a heated state as nearly to approach to ignition. It is true, that the timber, when this has been the case, has been decayed, but it is only from a confusion of terms that it is attributed to the dry-rot, for no fungus is then found: the wood, by intense heat long continued, having lost all its moisture, resembles that which has been for a length of time exposed to a great degree of artificial heat in an oven, so as to be nearly carbonized; and it is this which has destroyed the timber in question.

The decay of new ships, or such as have been recently repaired and sent to warm climates, is to be attributed to a variety of causes rather than heat alone; in ships built of oak, the rays of the sun, or the high degree of temperature of the air, causes the planking, which, perhaps, may have been recently cut, to shrink; the caulking, if not particularly attended to, becomes loose, the rain-water finds its way into the frame, and the de-

composition of the timber is the consequence; so that it is from the combination of these circumstances, and not to the heat alone, that their decay is to be attributed. Teak-timber, which contains a considerable quantity of oleaginous matter, is not much affected by a change of temperature, and alters very little in volume in consequence of heat; hence ships, constructed of this wood, remain in warm climates a great length of time without injury, and there are but few instances (although some have been found *,) of the dry-rot having been discovered in ships constructed of this species of timber.

The introduction and free circulation of atmospheric air, for the prevention and cure of the dry-rot, come next in order, under consideration. It would be useless to comment at large upon the durability of timber constantly exposed to a free circulation of air moderately dry, or to cite the many instances of almost daily observation in cathedrals, public halls, and other buildings in this country, in which the buttresses and supporters to the roofs, formed of timber, have remained for many centuries apparently unimpaired; for there remains no doubt, that where ventilation can be carried to a considerable extent, it is not only the cheapest, but most efficacious of remedies. But unfortunately in ships, a draught of air cannot be applied in all parts so effectually for this purpose, as to confide in it as a complete preventive; however, its introduction by openings made

* Some of the ceiling in the hold of the Salsette, built of teak at Bombay, in the year 1806, was discovered, in 1819, to have the dry-rot.

within board is a matter of much importance. That some of the fungi, which have been found on the timber in ships, will grow in the open air, if there be a sufficient degree of nutriment, is certain, the *Boletus medulla panis*, for instance; but the circulation of air through the frames of ships is useful, as it carries off the moisture, hinders fermentation, and by these the growth of this and other fungi is prevented. Such is the value to be attached to a free circulation of air when it is not loaded with humidity; and to regulate ventilation, in this particular, openings made within board are to be preferred to those without side the ships, as by lifting the port-lids, or keeping them shut according to the state of the weather, a circulation of the air may be promoted or retarded. To give the many instances where ships have derived benefit, even by the partial ventilation that can be brought about in many of them, would be to furnish a list of all those laid up in ordinary. It remains then only to be noticed, that as much of the materials as can be removed from within board, without materially weakening the ships, should be taken out to facilitate this object.

Moisture, like heat and air, when confined or present only in a small quantity, brings about fermentation in the timber, and is very efficient in promoting the increment of fungi; when ships have been exposed, half finished, for some years to the vicissitudes of the weather, the water that has insinuated itself between the timbers and plank, and which cannot be carried off for the want of a circulation of air, causes the materials to rot, and the ship to be speedily useless. Among many instances of a like

nature, the Dartmouth of forty-two guns may be quoted: from a derangement in the pecuniary concerns of the person who contracted to build that ship, she remained for some years on the slip in an unfinished state, but having much of the planking both within and without side worked, shortly after being launched it was discovered that the dry-rot existed to such an extent, that it was found necessary nearly to rebuild her; so that within three years after having been finished, and without having been employed at sea, the frigate in question was nearly destroyed. Such are always the effects in ships, in which water insinuates itself, from the want of being from time to time properly caulked, or other precautions taken.

As a small degree of moisture promotes the destruction of wood, so a great quantity, or total immersion, will preserve it for an indefinite period; there are innumerable instances of timber having been taken out of rivers in a sound state, which had remained there as piles or for other purposes, hundreds, nay, thousands of years; this may arise from the absence of air, and by the wood being kept in a comparatively low temperature. It was the custom in this country (as is stated in the third chapter,) at the end of the seventeenth and beginning of the eighteenth century, to immerse timber for a given time in water; this custom has been lately renewed under the notion of preventing the dry-rot, and it probably arose from an observation of Mr. Sowerby's in his second report on the Queen Charlotte, dated February 1813, "that there are very few fungi that will grow upon wood that is covered by water, although that wood

may be in a state of rapid decay." Different views have been taken of this practice ; some have supposed, that the sap is soaken out even from the heart of the timber, and thus fermentation prevented; while others have considered that the salt in sea-water kills the seeds of fungi, and also from its anti-putrescent quality, prevents decomposition. With respect to the first, it has been shewn in a former part of this work how long a time is required, and how difficult it is to impregnate with any liquid, even very small pieces of wood to their centre ; and with regard to the latter, a small quantity of salt increases, and promotes putrefaction and vegetation. Sea-water not only contains the muriate of soda, but also those of magnesia and lime: in common culinary salt, these are the chief causes of its deliquescent property, and impair (as they are in themselves highly septick,) its anti-putrescent qualities. What confidence then is to be placed in the immersion of timber in sea-water, as it regards its anti-putrescent nature, when a gallon contains only five ounces and a half of these salts; when the saturating, nay, afterwards boiling timber in water, holding nearly nine times this quantity in solution, has been attended with no practical good? If well-conducted experiments should, notwithstanding, prove the importance of immersing timber, particularly in salt-water, the benefit must be attributed to other causes than the anti-putrescent nature of that liquid. A resistance to putrefaction is attainable in a greater degree by a solution of many of the salts, than the muriate of soda ; alum, for instance, is thirty times more efficacious for this purpose.

It has been a common observation, that those vessels in which salt had been conveyed, as well as such in which it had been extensively used, have proved to be very durable; the Dutch busses, for instance, used for the purpose of curing fish, remain for a long time without decaying; this has induced that nation, in several instances, to make their ships, storehouses for salt, and also to put it between the timbers of their frames for the purpose of preserving them; this was also done partially in this country about the middle of the last century *, and has been lately much practised by the Americans. The owners of new ships trading from ports in the Baltic, are always anxious to procure salt as a first cargo, under the notion that it ensures their durability. But it is a consideration, whether in this instance, as well as in that of ships carrying lime, favourable effects may not have been brought about by the strong affinity that the muriate of soda, and also lime, have for water, and by their depriving the timber of its superabundant moisture, rather than to the anti-putrescent qualities which they possess. But the advantages or otherwise of using salt for the purpose of promoting the durability of ships, or preventing the dry-rot, may be judged of by the following instances, the one being unfavourable, the other in favour of that practice. The Florida of twenty guns, built in the year 1813, at Charlestown in America, and captured from the Americans in the year 1814, had been what is termed salt-seasoned, by

* Dr. Hales, in his work on *ventilation*, published in the year 1758, gives the proposition of putting salt among the timbers of ships, to a Mr. Reid, owner of the salterns near Portsmouth.

having pieces of wood placed between the openings of the frame, on which large grained salt (commonly called bay-salt,) was put, so as to fill up those spaces. Much inconvenience was experienced while she was in commission, from the deliquescent property of this salt. In January 1819, the ship, on her arrival at Chatham-yard, "was found to be in a very damp state, and also to be generally defective, so much so as to render it advisable to take her to pieces;" which was done in June 1819, "when it was discovered that fungus was growing on the timbers that had salt on them." An American merchant-ship, the Messenger, of 277 tons, that had been salt-seasoned, has been lately examined by the officers of Portsmouth-yard; she was built generally of white-oak, at Salem, in the year 1805, and the openings between the floors and timbers, from the limber strake to the gunwale, were filled with salt of a strong quality, purchased at the Cape de Verd islands; thirty-five hogsheads were expended on her; pieces of wood were fitted between the floors to prevent the bilge-water from getting to the salt: since the year 1805, the openings have been refilled six or seven times, but on the recent examination (June 1820) no salt was discovered therein; the vessel was stated to be, from exterior examination, "in an apparently dry and sound state."

The fact, that detached pieces of timber remain for a great length of time in a sound state under water, naturally leads to the conclusion, that buildings composed of wood, such as ships, would also endure for a long time, if immersed; provided their

metallic fastenings were not oxidized, or the timber destroyed by the *teredo navalis*, a worm that abounds in the sea. In fresh-water the metals remain without oxidation, and there are no worms; in salt-water, iron is very soon affected; the other metals suffer, but more slowly, and in most situations worms destroy the timber. Immersion, therefore, in the latter can only be used for a short period, and if ships be sunk in either, it is obvious that the progress of the dry-rot will be stopped, from the fact before stated, that "very few fungi grow on timber immersed in water, even if that timber be in a rapid state of decay," but it is not so obvious that when the ships are raised, a recurrence of the evil will not take place. Trajan's galley, built chiefly of cypress and larch-wood, remained sunk in Lake Riccio, for more than 1,300 years, and when weighed, was found to be in a sound state.

The notion of filling ships to a certain extent with salt-water, in order to their preservation, is of ancient date. In the year 1699, a proposition was received from J. Hammond, a ship-wright in Portsmouth-yard, to take out some of the short-stuff between the ports of ships, and to fill their frames by means of syringes with salt-water *; at that time the plan was considered to be visionary; but in the year 1720, two ships of the line at each of the ports of Chatham, Sheerness, Portsmouth, and Plymouth, had six, seven, or more feet of water, according to

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* It is proper to state, that at this period, the seams of the footwaling as well as those of all the other inside stuff were caulked.

their respective sizes, let into their holds; which remained there for three of the summer months, in order, as it was stated, "to prevent their fore and after bodies from heating;" and the dock-yard officers were directed to select those ships, which had been most recently built or rebuilt; unfortunately, there are no records that shew how this experiment answered. Filling ships with sea-water has been recently recommended* for the cure of the dry-rot, the method proposed is as follows: "The inside of the ship to be stript as much as possible, after the ballast is taken out, and all the fungus which appears on the timbers carefully scraped off. The ports should then be caulked so as to render them water-tight. Valves should be prepared in the sides, which might be opened and shut at pleasure. The ship should then be filled by means of these valves, and when she is brought to a proper depth, they should be closed. In order to prevent the unpleasant effluvia which arises from stagnant water, it might be occasionally changed by pumping the ship, and again admitting fresh-water by means of the valves. She should remain in this state until it be ascertained by boring, that the water had reached the centre of the timbers, and that they are perfectly saturated. After remaining in this state for a short period, she should be taken into a dock that is roofed, and opened in various places, that no part might be without a circulation of air; she should then be washed and cleaned

* See a treatise on the dry-rot by A. Bowden. The society of Arts, in the year 1818, voted their gold medal to the author, for recommending, for this particular object, an extension of the practice of filling ships with salt-water.

agreeably to the recommendation of Mr. Snodgrass; and after standing to get perfectly dry, such timbers as are found to be decayed, should be removed, and sound old timber only should be used in her repairs." It would be useless in this place to point out the inconveniences and difficulties that would be experienced, not to say the impossibility that would be found, in attempts to carry the plans of filling the interstices between the frames, or the ships by valves with water; because a better and more effectual method presents itself, and which has been put in practice, that of *sinking* a ship in salt-water. The notion, however, is by no means new. J. Hammond, the shipwright before alluded to, being foiled in his object of filling the openings in the frame with salt-water, renewed in the same year (1699) his opinion of its advantages, "to prevent the ships from heating;" and proposed that "a ship should be sunk for three months, and another of equal newness be always kept dry, and to make the observations (as to comparison) five or six years afterwards." In making this recommendation he asserted his conviction, "that a ship may be sunk one day, and made swim the next;" this, however, met with the same fate as his former proposal.

About the year 1780, a proposition was again made to sink ships for their preservation, but no steps appear to have been taken in consequence *; it was not until the year 1816, that

* This is given upon the authority of Nicholas Diddams, Esq., master shipwright of Portsmouth-yard; but as he does not recollect the name of the party, the author has not been able to trace the original paper.

this method was practised for the cure of the dry-rot. The sinking of a ship took place in consequence of Sir R. Seppings having observed, in visiting the dock-yards, that the Resistance frigate of forty-two guns, and the St. Fiorenzo * frigate of the same force, had no appearance of fungi, the former having been sunk by accident while she was being hove down in the Mediterranean, and the latter from the effects of shot fired at her in St. Fiorenzo bay. They were both afterwards weighed. These instances induced Sir Robert to believe, that the salt-water had had the effect either of killing or preventing the growth of fungi, and he proposed to sink the Eden of twenty-six guns, which ship was built at Chester in the year 1814, and shortly after being launched, was found to be much injured by the dry-rot. In November 1816, the cabins and store-rooms were removed, openings made in the hold and sides within board, to admit the water into the frame when sunk; holes formed in the bottom to let in the water to sink her; and plugs attached to keep it out when she might be weighed. Bilge-ways were fitted to preserve her, when immersed, in a perpendicular situation. The Eden, being thus prepared, was sunk in Barnpool near Plymouth, on the 9th November 1816, and remained in that state until the 12th March, 1817, when she was weighed, and the water pumped

* The St. Fiorenzo is one of the many instances which may be given of the superiority, in point of durability, of the French ships built at Toulon; this ship was built in the year 1782, had some repairs in 1792, was captured by the British ships in the Mediterranean, in 1793, was employed for many years as a frigate in his Majesty's service, afterwards as a troop-ship, and is now used as a receiving ship at Woolwich, without having undergone a regular repair.

out. It was found that the iron work in general, was corroded, and the smaller articles of that metal, such as nails, were nearly destroyed. Much of the planking was then removed from the ship, in order to dry the materials, by a circulation of air, and she remained in that state until the 9th February 1818, when she was taken on a graving slip; the whole of the wales, the sheer-strake, and a considerable portion of the top-sides were removed, and all the defective timbers and planks shifted. A considerable quantity of fungus was found, but none in a growing state. The ship, after this repair, was put into commission and sent to the East Indies, where she now remains.

Although no fungus was found in the Resistance and St. Fiorenzo, and the immersion of the Eden had killed that which was growing in her, still these experiments do not appear conclusive as to the fact, that this species of vegetation will not grow upon timber which has been water-soaken. It is evident that the Resistance and St. Fiorenzo had not the dry-rot when they were sunk; for if it had existed, fungus would have been found, in either a dead or living state, when these ships were examined to ascertain the fact. And with respect to the Eden, she was not only sunk, but was afterwards opened for a circulation of air through the frame, and subsequently had all the defective timbers and planks shifted; and there are but few instances of a recurrence of the dry-rot in ships, when the fungus has been taken away, and the timbers and planks so affected exposed for a time, to a free circulation of air. But should it be ascertained by many well-conducted experiments that the immersion

of timber for a given period, is a preventive or cure for this species of decay, it will surely be wiser to follow the trite but not less true adage, that "a preventive is better than a cure," and revert to the practice of soaking the timber in fresh or in salt water, than incur the hazard and expense of sinking the ships to attain these objects. In the summer of the year 1815, the Americans sunk their flotilla on Lake Erie, in order to preserve them from decay.

The sound condition in which those floors and first futtocks that lie horizontally in ships, are usually found, has led to the conclusion, that this is produced by the damp state in which they are continually kept; but there is reason to believe that their being protected from the influence of the air, by being covered with the iron or shingle ballast, contributes also to this effect.

Ships which leak considerably, have no fungus in those parts where there is a constant run of water, and they have been found to be healthy to their crews, from the necessity which exists of pumping them continually, which not only carries off with the water, the carbonic acid gas * from their holds, but creates a rapid circulation of air. But for this, leaky ships would be un-

* The carbonic acid gas, formed from the breath of the crews and the decomposition of the timber, being heavier than atmospheric air, naturally descends, by its gravity, into the hold, and is absorbed by the water in the pump-well. Water, at a temperature of forty-four degrees, has the power of holding its own bulk of carbonic acid gas, and if its temperature be increased, its power of absorbing that gas is enlarged.

There are innumerable instances of the loss of life, by seamen descending into the wells of ships, (when proper precautions have not been taken,) from the effects of this gas, united, perhaps, with the sulphuric effluvia arising from the bilge-water.

healthy from their continual damp state, as it has been abundantly proved that those which are dry, when kept clean, are in all cases, the most salubrious.

It has been reasonably supposed, that the introduction of metallic sheathing* has had the effect of lessening the durability

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* Perhaps the sheathing first put upon ships' bottoms to protect them from the worms, was hides of animals covered with pitch, or with asphaltum; this led to the use of thin boards, having in some cases lime, and in others lime and hair, between them and the bottoms of the ships; the former is now practised in the East Indies, with the lime formed from calcined shells called *chunam*. The use of metallic sheathing is, however, of ancient date; the galley supposed to have belonged to the Emperor Trajan, and which was weighed after it had remained for more than 1,300 years under water, was sheathed with sheets of lead, which were fastened with copper nails. In the year 1670, an act of parliament was passed, granting unto Sir Philip Howard and Francis Watson, Esq., the sole use of the manufacture of milled lead for sheathing ships; and in the year 1691, twenty ships had been sheathed with lead, manufactured by them, and which was fastened with copper nails: this practice was, however, discontinued, in consequence of the rother irons being speedily corroded by their forming with the lead and sea-water a simple galvanic circle. The Spaniards and Portuguese at that time, employed the same method of sheathing their ships. The use of lead was, however, revived in the year 1768, in order to prove whether it was equal to copper sheathing; the bottom of the Marlborough, of sixty-eight guns, was covered with lead at Chatham in 1768, and was then sent to Sheerness to be laid up in ordinary: she was docked at Chatham, April 1770; it being then found that the lead was covered with weeds, it was removed, and wood sheathing substituted. In the year 1693, a Mr. Bulteel invented a metallic sheathing, and gave a notice thereof in the *Philosophical Transactions;* (8th volume, 6,192 page) it appears from the description given, to have been a mixed metal, but chiefly lead. In the year 1761, copper plates were first used as sheathing on the Alarm frigate of thirty-two guns; from that time until 1783, the practice was gradually introduced, but in the latter year it became general. Many experiments have been tried to ensure the durability of the copper sheets, either by painting or varnishing their inner surfaces, but the use of brown paper which has been dipped in tar, and placed between the wood and copper, is now considered to be the best mode. Plates of zinc were proposed for the sheathing of ships in the year 1816, by Mr. Chaulet, and said by him to be

of ships of war, and promoting the dry-rot, from the circumstance of their not being required frequently to be taken into a dock for the examination of their bottoms, and consequently not so often unstowed. When ships were sheathed with wood, they were usually docked every two years, but a period of three years never elapsed without their being breamed and graved. The benefit arising to ships from being frequently unstowed, is proved in colliers and transports that deliver cargoes many times in each year, than which no vessels are more durable. During the late wars, the ships employed on foreign service, remained

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practised in France; plates of this metal, however, had been previously manufactured in England, and used on some merchant-ships; they were found to break by the working of the ships, to be soon oxidized by the marine acid, and to be very foul with weeds. In the year 1818, Mr. Collins proposed to manufacture sheets composed of eighty parts of copper, and twenty of tin, but it could not be rendered sufficiently malleable to pass through the rollers. Copper sheets when introduced, were fastened with copper nails one inch and a half in length; these were substituted by those of mixed metal, which is now the practice, as it is found that they hold better than copper, from their rough surface. Pure copper nails were again tried in the year 1805: they soon worked out of the bottom, and the mixed metal was again substituted. It is said that tinned plates have been used, but no authentic account thereof has been found. A metallic sheathing has in some cases been brought about, by driving large-headed iron nails into the sheathing board, which by oxidation caused a metallic crust to be formed over the bottoms; this was called filling; it has, however, been discontinued. A felt composed of hair, manufactured by a Mr. Wood, has been used for the protection of ships' bottoms from worms, by being placed under the sheathing, with success; this was put upon the Isabella, and Dorothea, ships employed on the voyage of discovery to the Arctic regions, and, probably, prevented their foundering when crushed with the ice. The use of copper tinned, might be productive of advantage; the only difficulty that presents itself, appears to be the small quantity of tin that can be placed upon copper, according to the process at present made use of in tinning articles, used for culinary purposes.

on their stations five years; and there are instances of their keeping the sea without being hove down or docked, even for a longer period; hence one of the causes why the dry-rot was more prevalent, and ships did not last so long during those periods as formerly.

The knowledge of the fact, that bodies do not alter or decay *in vacuo*, has induced the notion, that if timber were covered with an insoluble coating, impenetrable also to air, it would endure without change. Taking this view of the subject, Dr. Parry in his essay on the *Dry-Rot*, published among the papers of the Bath and West of England Society, has recommended, that the timber should be covered with a varnish *, to protect it from decay and injury from fungi. In ships, however, this plan cannot be carried into effect to the extent proposed, for the varnish would be displaced, and the air admitted by boring the many holes in each timber for the admission of the numerous fastenings. With the same intention, and to prevent in a measure, the timbers of the frame from rending while seasoning, foreign nations have covered them with a coating made from selenite, lime, and in some cases with paint; but all coverings of this nature, except the timber be in a dry state, are injurious, as there generally is, in unseasoned wood, a sufficiency of air as well as moisture, to bring about internal decay. This defect has been erroneously

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* Dr. Parry's varnish is made as follows: take twelve ounces of resin, eight of roll brimstone, three gallons of oil, and four ounces of bees'-wax; boil them together, and lay them on the wood while hot.

considered by some, to be the dry-rot; but this species of decomposition is found commonly in timber which has been long water-soaken, and which, if exposed for some time to the air, although it may present externally, a sound appearance, is found to be in a state of internal decay, without, however, exhibiting any fungi. In some cases hair, in others thin sheets of metal, or oiled and tarred paper, have been put between the faying surfaces of the timbers; the metals, however, in particular, when so used, have been found to accelerate rather than retard, decomposition; it is, however, right to observe, that if the timber be covered, or in other words, insulated by any substance through which the fungi cannot shoot or take root, the dry-rot is necessarily prevented.

In the ships wholly constructed since the peace, (1814,) there has been no instance discovered of the dry-rot: this has been attributed by many persons of observation and considerable information, to the use of coal-tar. There is no doubt but the article in question has contributed to the preservation of the ships, but their universally sound state is not to be confined to the use of this tar alone, but to be assigned to a variety of causes; converting the frames of ships, and laying them apart a considerable time before they are put up,—building them under cover,—their having solid bottoms,—the ventilation afforded by the use of shelf-pieces,—painting the faying surfaces,—the openings made within board to admit air, and the care taken of them as to cleanliness, while in a state of ordinary, have jointly and severally, (with the coal-tar,) contributed to this effect. It can

be asserted with confidence, that at no period of our naval history, has England possessed a fleet more efficient, or in better condition, than at the present time.

Some authors have considered, that the dry-rot takes place in the centre of the timber, and thence proceeds to the circumference; that, in fact, it is an "internal disease." If this were the case, all the preventives and remedies before stated, which have been applied, and others recommended for the purpose, would be useless; as experiments have proved the long time it requires, and the difficulty, not to say the impossibility, of impregnating large pieces of timber to their centres; thus the use of coal-tar, the immersion in fresh or sea-water, salt-seasoning, *&c.*, would be useless if not prejudicial, as their influence extends but little beyond the surface of the wood. The opinion that it is an "internal disease," can have arisen only from a confusion of ideas, and a want of knowledge of what the dry-rot actually is; and the recommendation of impregnating trees to their centres, with water or any other liquid, to prevent the disease, must have proceeded from a want of knowing the impossibility of doing this by common means, in any reasonable time. Although it is probable, that the seeds of fungi may be lodged in the timber, and only require a proper nidus to call them into life and action; yet hundreds, nay thousands of experiments have proved, that the destructive influence of the fungus is on the surface, for when that is taken off the wood, by dubbing or otherwise, if it has not been of long continuance, the timber under it is uniformly sound, and there are few instances of any recurrence of the dry-rot.

On the contrary, if it took place in the centre, and then proceeded to the superfice, the further the timber was cut into, the more unsound it would be found. Every day's experience proves the fact, that the action of dry-rot is on the surface of the wood; and from this knowledge, we may fairly reckon upon the expediency of employing external means, both to cure and to prevent the disease. This fact, however, should never be lost sight of; that well-seasoned timber not only in itself prevents dry-rot in a great degree, but aids also any other means that may be employed for the furtherance of this object.

CHAPTER IX.

ON THE DURABILITY OF THE SEVERAL KINDS OF TIMBER, EMPLOYED IN THE CONSTRUCTION OF HIS MAJESTY'S SHIPS.

IN comparing the durability of ships comprising the navy at different periods of our history, striking alterations appear to have taken place therein. In the middle of the seventeenth century, thirty years * was considered to be the period that a ship lasted; at the early part of the eighteenth century, fourteen years † was accounted the time, and from the result of the experience gained during the late wars, the average duration of ships did not exceed eight years before they required very extensive repairs. The mercantile navy is also considered to be less durable now than formerly. As no effect can be produced without an adequate cause, some persons have ascribed the

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* "Forasmuch as a ship doth commonly reign about thirty years, it follows, that the one-thirtieth part of the tons of shipping, of which the whole navy consists, must be new-built every year."—Sir W. PETTY's *Naval Philosophy*.

† In Sutherland's "*Ship-building Unveiled*," published 1729, (second edition,) it is stated, "that the ships were tore to pieces and rebuilt in less than fourteen years, which, in former times, used to continue thirty years, with but very slender repairs." In the year 1759, the ship-builders in the river Thames, gave as their opinion, that the durability of a river-built ship, might be reckoned at sixteen years.

present early decay of ships to arise from felling the timber in the spring; others from the introduction into this country of foreign acorns, in order to produce trees quick of growth; while there have been those who, with some degree of plausibility, have attributed it to a want of chemical affinity in the juices of the timber, brought about by an admixture of different kinds of foreign wood with the British oak, in the construction of the same ship. So much has been said in a former part of this work, about felling timber at different seasons of the year, as to make it useless again to enter into the argument; and with regard to the quality of oak-trees, those which have grown on a good soil under other favourable circumstances, are still found to be durable, if they be properly seasoned before being brought into use. With respect to an admixture of woods, those ships built by merchants for his Majesty's service, in the construction of which, British oak only was employed, (with the exception of their bottoms and weather-decks, which have been for time immemorial planked with oak and fir brought from the Baltic,) have not been more durable than those constructed in his Majesty's yards, in which timber of many kinds have been used, always excepting that imported from Canada.

The more rapid decay of our ships has arisen, from the altered nature of the service on which they are employed, and the necessity during war, of constructing them in haste with unseasoned materials. In former times, ships, even during periods of hostility, seldom or never kept the seas in the winter months; so that they were completely sheltered in harbours from the storms

incident to that season*. And as their number was not considerable, there was a greater choice of materials, which were not used until they were in a comparatively dry state. A more active degree of warfare gradually came into use, and of late years, it has been the custom for the fleets to keep the sea at all seasons of the year: hence the greater wear and tear, and to this, combined with the use of green wood, the rapid decay of the ships is to be attributed. The extension of commerce, and consequently the greater activity required in conducting trade, has had the same effects on our merchant ships; for while in former times, after having made a voyage or particular voyages, they were laid up the remaining part of the year, they are now actively employed during all seasons, which has tended to decrease the term of their durability. Another circumstance may have conduced to a belief that the ships of the royal navy are less durable now than heretofore; for in order "to make assurance double sure," they are opened in every part, and defects searched for with the most scrupulous attention; a practice which did not formerly exist, for while by the present method, many ships are laid up in ordinary as not sea-worthy without

* All those ships, whose periods of durability have far exceeded the ordinary course of things, have been stationary in harbours; for example, among a number of others, the Royal William, of eighty-four guns, which ship lasted ninety-four years, lay during that period ninety years in harbour. The Chatham sheer-hulk, which lay at Chatham, was built in the year 1694, and was taken to pieces in 1813. The Gladiator, of forty-four guns, on two decks, built in 1783, lay in Portsmouth harbour until the year 1817, and was then taken to pieces, not on account of any particular defects, but because a ship of that class was not wanted during peace.

repair, if this rigorous examination did not take place, they would keep the seas without shewing any symptoms of defects.

In giving an account of the different kinds of timber which have been used in building his Majesty's ships, and of the durability of the several sorts, particularly those imported into this country, for the purpose of lessening the consumption of British oak, it is not intended to inquire how far it is prudent to encourage our own colonies, by purchasing, exclusively or in part, timber of their production; or whether a balance of trade should be preserved with foreign nations by taking in exchange for colonial produce, or manufactured goods, wood, which is perhaps, almost their only export; or how far, the shipping interests may be concerned, in encouraging one particular line of commerce in preference to another; for these are subjects for the politician to discuss and decide upon, and change from time to time by the occurrence of political events; but solely to give from the results of experiments, an account of the different qualities and particularly the durability of the timber used, in the construction of the royal navy.

Oak has hitherto been considered not only the strongest, but the most durable timber grown in this country, and from these circumstances, it has been extensively employed in the construction of our ships; but as its qualities and uses have been already treated upon so much at large, no further notice appears to be requisite.

Elm* is used for the keel and garboard strakes, and sometimes for some of the lower strakes of the bottoms of ships; it is a wood

* The shells of blocks, dead-eyes, and pumps, are made of elm.

the texture of which is tenacious, and when kept either under water or in a dry situation is durable, but placed where it is alternately wet and dry, it very soon decays.

Beech has also been employed for the garboard strake, and for some of the lower strakes of the plank of the bottoms of ships, particularly a-midships : like elm, it is found to be durable only in situations where it is not subject to frequent changes.

Larch timber, grown in Scotland, was first used in the British navy in the year 1809 ; his Grace the Duke of Atholl having sent to Woolwich yard in that year, eighty-one loads of this timber, the produce of his estate at Dunkeld ; it was brought into use, some in the Serapis store-ship ; a part in the Sybille frigate ; and the remainder for the planks of the bottom of the Woolwich lighter, for piles driven into the mud which were alternately wet and dry, and for skids on which timber was piled ; and in all these situations it appears to be a durable wood. Its further qualities are likely to be put to the test, in the Athole of twenty-eight guns, which ship has been constructed solely with larch that was felled, some in the summer and some in the winter months of the years 1816 and 1817, with the exception, however, of the flats of the upper-deck, quarter-deck, and forecastle. It is proper to remark that this wood appears to be well adapted for decks, and it would have been used for them if there had been sufficient in store, which was not the case from some misapplication of the timber, or incorrect calculation as to quantity. The Athole was launched on the 23d November 1820.

The larch timber in question is of two kinds, the white and the red ; in the former, the sap-wood is hardly distinguishable from

the heart, and although the alburnum in both is more durable than that of most other trees, yet it has been found to decay much sooner than the heart of the timber. It has hitherto been considered that the worms in sea-water will not injure this wood, but by an experiment made at the Nore, this opinion appears to be unfounded. Larch is of a very tenacious quality; in boring the treenail holes, a core was produced by the auger almost solid, a property which no other known wood possesses to that degree*.

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* The aforegoing account of larch is all that arises from the experience which has been had of its uses in the dock-yards; but the author is enabled by the friendship with which his Grace the Duke of Atholl is pleased to honour him, to give additional particulars, which cannot fail to be interesting to the public, at this time, in particular when the larix, or larch-trees, are being extensively planted in all parts of the United Kingdom. Seedlings of larch were, probably, first brought into Scotland, in the year 1738, by Mr. Menzies; but it has been asserted by some, that they were introduced into that part of this country, in 1734, by Lord Kames. Some were left at Dunkeld, and some at Blair Atholl, by the former gentleman, and being exotic plants, were placed by the gardeners in green-houses; not thriving in those situations, they were planted in the pleasure-grounds, where they grew luxuriantly. When the present Duke succeeded to the titles and estates, (in 1774,) there was a considerable number of trees in a thriving state, and on a general survey of his estates in 1783, there were found to be 900 Scotch acres of plantation, 600 of which were of larch: since which time his Grace has planted extensively every year, and in the spring of 1820, 10,820 Scotch, or about 12,984 English acres, were covered with trees; the different species were of

Oak	800 Scotch acres.
Scots firs	1,500
Spruce firs	500
Mixed plantations in the pleasure-grounds	200
Birch	200
Larch	7,620
	10,820

The method of planting the larch-trees is as follows: 2,000 seedlings, of two years

During the time that this timber lay in piles in Woolwich dock-yard, exposed to the weather, neither the heart nor sap-wood was in the least decomposed, nor was there the slightest appearance of lichen or fungi growing upon any of it.

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old, are planted on each Scotch acre, and put six feet apart; these as they grow up are gradually thinned to 380 on each acre, standing twelve feet asunder, and at that distance they are left for timber-trees; the cost of the 2,000 plants is 3*s*. 6*d*., and the expense of labour for putting them into the ground 2*s*. per acre. The whole charge for planting, enclosing the ground, and of making the roads, including also the interest of the money first expended, is more than paid by the sale of the trees taken out in thinning the plantations. The larch thrives in very exposed situations; the lower range of the Grampian hills, which extends to Dunkeld, are at an altitude there of from 1,000 to 1,700 feet above the level of the sea; the larch-trees are planted as high as 1,200 feet up these hills, and grow exceedingly well; a situation where the hardy Scots firs cannot rear their heads; the spruce fir, however, thrives equally well as the larch on high and exposed hills. The growth of the larch-trees is very rapid, a Scots fir of the same age will measure only half the quantity, and so much is the wood esteemed in Scotland, that while the former is worth 2*s*. 6*d*. per cubic foot, the latter brings only 1*s*. 3*d*. The following account of a larch-tree, planted in the year 1738, and measured February 1819, will give some notion of its growth.

	FEET.													
Above the ground at -	1	2	3	4	5	6	10	20	30	40	50	60	70	75
Girth - - - - - - -	ft. in. 17 8	14 6	12 7	11 9	11 5	11 1	10 4	9 7	8 11	7 11	6 3	4 8	3 2	1 10

The top was fifteen feet in height, making the whole height ninety feet, and the tree measured 300 feet or six loads in cubical contents. The white and red larch-trees, are those chiefly planted; the Duke has made trial of the black or American, and also of the Russian larch, but has found that they do not thrive well. The timber in question has been used for many years in Scotland for almost all local purposes, such as posts, rails, mill-wheels, fishing and ferry-boats; and in all these situations has been found to be very durable. The author has seen part of a ferry-boat twenty-three years old, which remained very sound, and the iron-nails driven into it as

Some Scots fir has within a few years been delivered into the dock-yard at Woolwich, which grew in the forest of Marr, upon the estate of the Earl of Fife; it appears to possess strength, but the quantity was too small to be brought sufficiently into use, in order to judge of its durability.

Spruce spars, grown in Scotland, have been supplied by the Duke of Atholl and converted into masts and yards (with the exception of the lower masts,) for the Athole frigate; they appear to be spars of a close texture, to possess strength and

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perfect as when they first came from the forge; this, perhaps, was occasioned by their being constantly covered with an insoluble varnish, (the Venice turpentine of the shops) with which the larch abounds. The Duke of Atholl has recently built a vessel of 170 tons, wholly of larch, the necessary knees and crooks, being formed from the roots of the trees, the lower masts and boats are also of that wood, the topmasts and yards of spruce firs, grown upon his estates. One of the qualities of larch for building merchant-ships, is, its great lightness, a cubic foot weighing, when seasoned, (which it does rapidly) only thirty-four pounds; although it is not so strong as many sorts of woods, it has great resilience. Cabinet work of great beauty has been made from larch; it polishes well, and when seasoned is not found to warp or shrink. In addition to its other properties, it is slow of combustion, and is said to let shot through without splintering. A most important fact in agriculture has arisen from planting larch-trees on rocky ground; the vegetable compost formed thereon by the falling of the leaves, has been the cause of producing herbage for feeding cattle, and made that land which on the average did not formerly bring more than 8*d*. or 9*d*. per acre, now to be worth from 12*s*. to 14*s*. per acre annually. Swift has stated, that "whoever could make two ears of corn, or two blades of grass to grow upon a spot of ground where only one grew before, would deserve better of mankind, and do more essential service to his country, than the whole race of politicians put together." How much more of praise, then, is due to his Grace of Atholl, who, has not only furnished, what were barren hills, with trees whose lofty heads seem to tower to the skies, but has also been the cause of clothing the sterile rock with fertility, in the end to allay the wants or add to the luxuries of mankind.

great elasticity, but are rather subject to knots, which, however, are well collared*.

Chestnut is, when stripped of its bark and sided, so much like oak, that in some instances it has been received as such, and worked into ships; when this has been the case, it has been discovered in a short time by its being in a decayed state. When a doubt arises whether the timber be chestnut or oak, the usual method of detection is to put water on the saw: if it be the former wood, it will not be discoloured; but if the latter, the water will dissolve the gallic acid, and this acting on the iron, will, in a degree, cause oxidation, and leave a black stain on the sides of the timber through which the saw has passed.

Adverting to the timber imported from the Continent of Europe, mention should first be made of the oak plank shipped in the Baltic, and chiefly from the port of Dantzic, under the denomination of Dantzic oak plank. This is generally of the growth of Poland, is cut in that country in the winter, converted into plank, and when the rivers and canals are open, floated down to Dantzic. The plank in question has been used for centuries past, upon the bottoms of ships of war, in all cases on the lower deck, and that part of the middle deck of the ships of the line where the guns are trained, and sometimes upon their topsides. Under water, in particular, it is found to be so durable that generally when most of the timbers of ships are decayed,

* If we may give credit to Charnock, Scotland has produced masts of very large growth; he says, "the main-mast of the Royal William, of three decks and eighty-four guns, was made of one stick grown in Scotland."

their bottoms are sound, indeed in this situation it commonly wears out two sets of frames; it is equally excellent for decks, particularly those where heavy guns are placed, as it is not so subject to be worn by the trucks, and the guns are worked with greater facility than upon fir decks *. The Dantzic plank is not of an uniform quality; and the Prussian government has, from the repute in which it has been so long deservedly held and the consequent value of the trade, appointed officers to mark its relative qualities, that purchasers may not be deceived: these officers are called Braakers, and they place upon plank of the best quality the letter K; that of a secondary one was formerly marked with a B, but now with a W, which denominates it to be single-braaked; and that of a third, or inferior quality, formerly with BB, now with WW, or double-braaked. The crown plank (K) has usually been contracted for by the British government, until within two or three years; the quality is now left, without any consideration of marks, to the receiving officers; but it remains to be proved whether the judgment of persons employed in this capacity, who have many other concerns to attend, is to be put in competition with those always employed on the same pursuit; and whether it be prudent to give up this additional check, so wisely and properly enforced by the government of Prussia. In addition to the durable † properties which this plank possesses, the cheap rate at

* The French use oak-plank on almost all the decks of their frigates; it has not been brought so generally into use in England, on account of its greater specific gravity than fir, and in cold climates it has been found very slippery to the feet of the men in working the ropes which lead on deck.

† Mr. Pepys, in a preface to a small work entitled *Œconomy of his Majesty's Navy-*

which it can be purchased, is a consideration of moment *, and the method of converting it with square edges, free from sap-wood, makes its application economical; regard, however, should be had to its having undergone, before it is received, a proper degree of seasoning, the deterioration of this plank for the two first years after it has been cut, from its exhibiting radical defects, and the great shrinkage which takes place on all timber when cut into plank, may be averaged at about 10*l. per centum*, independently of the interest of the capital laid out.

Dantzic deals have been used for centuries past for the weather-decks of ships, and experience has proved that they are better adapted than any others for this purpose.

Fir timber, imported from Dantzic and Riga, has been employed in building many frigates and some sloops of war; that from the former port, although not so sightly in appearance as

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Office, mentions that the Commissioners, who met in the year 1686 to inquire into the state of the navy, represented that "nine of the most able builders in the kingdom gave it under their hands to the King, that the foreign plank is more durable, and every way better for the building of large ships than the English. This will startle many, who being fond of their own country, imagine that it affords every thing better than any other part of the world; and particularly the oak, which they conceit exceeds any in the world for building of ships; whereas so many knowing men, who spake not upon notion, but by experience, have so positively declared that the plank brought from Dantzic, Riga, and of the growth of Poland, Prussia, and Bohemia, does far exceed any of English growth: and this declaration of so many able shipwrights, was confirmed unanimously by the aforesaid commissioners; whereupon an order in council passed to authorize the Commissioners of the Navy to contract for foreign plank for the use of his Majesty's ships."

* The average price of Dantzic plank, is, at the present time, 15*l.* 15*s.* per load, 6*l.* of which is paid as duty to the crown; so that it may be said to cost the government about 9*l.* 15*s.* per load, for picked plank.

that from the latter, is considered superior in durability. The first frigates built in this country of fir timber, imported from the Baltic, were five of twenty-eight guns in the year 1757; and although the average durability was nine years, yet as the article was a novelty, there then existed a prejudice against using this description of timber * for building ships. In the year 1796, six frigates were built, and the like number were constructed in the years 1804 and 1805, of Baltic fir; their average duration was eight years, which is quite as long as frigates built in haste of oak. The low price at which Dantzic fir can be purchased, the facility with which it is worked, and the consequent decreased rate of workmanship, the slender loss in conversion, with the comparative higher value of the old materials, when the ships are broken up and the wood sold, render the building of frigates, and smaller vessels of these descriptions, of fir timber, a matter of policy †.

In 1772 and following years, a considerable quantity of oak, of the growth of Germany, was imported into this country, and

* In the fir frigates, it has been customary to use elm timber for the keel and floors, oak for the stems, stern-posts, and those timbers of the frame which form the sides of ports; but according to the new system of framing ships, introduced by Sir Robert Seppings, they will be built in future (with the exception of the keel, stem and stern-posts,) of fir only. This has been carried into effect in the Niemen of twenty-eight guns, lately launched from Woolwich dock-yard.

† Independently of all the advantages which have been enumerated of building frigates with fir, may be mentioned the great facilities afforded the constructors of designing good ships by the lightness of the material; this enables them to decrease the area of the midship sections in particular, and consequently, the resistance of the water on the bodies of ships becomes lessened, and the lightness of the topsides and the elasticity of the wood prevent the ships from racking on their fastenings.

employed in the building and repairs of ships; but it was subject to early decay, and although after it had been used for four or five years, it presented a fair outside, which, however, was a mere shell of about one-fourth of an inch in thickness, the inside was found to be completely decomposed. In the year 1802, a further supply of German oak was obtained, which grew in the province of Holstein, and used in building the Blake and St. Domingo of seventy-four guns each, and in the repairs of several ships; it was subject, however, to the same defects as that imported in the year 1772. The Blake was launched in August 1808, found to be unserviceable in October 1813, and sold in October 1816. The St. Domingo was launched in May 1809, found to be unserviceable in May 1814, and sold in April 1816. The importation of this timber has been discontinued.

A considerable quantity of oak timber and plank has been imported from the Adriatic, which completely justifies the opinion given of it in the first chapter, some being of a hard and good quality, and part having a more soft and open grain.

Some larch thick-stuff has been lately imported, the produce of the Tyrol and Carniola*; the trees from which it was cut,

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* The Larch, grown in the southern parts of Europe, was much esteemed for its excellent properties, by the ancients. Some critics have supposed, from the incombustible nature of this wood, that it is the shittim-wood of the Jews, and that the table kept in the Jewish ark for sacrifices, was of this timber. Pliny speaks in high terms of larch; he says "this tree, which is the best of the kind of those that bear rosin, likes to grow in the same places as the rest: but the timber is better by far, for it rots not, but will last and endure a long time, besides it is of a red colour." And after detailing the inflammable qualities of several kinds of fir, he continues, "with the ex-

appear to have been slow of growth: no experience has been had in this country of the durability of this species of timber.

Of the woods brought from Asia *, the teak from its great durability and superior strength, demands the first notice; it has been erroneously supposed, that this timber is not so proper for the construction of ships of war, on account of its weight; to disprove this, it is only necessary to mention, that although its

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ception of the larch, which neither burns in a light flame, nor makes a coal, nor consumes in the fire other than a stone." Adverting to the great size of the trees, he says, " the greatest tree ever seen at Rome, was that which was brought with other timber for the rebuilding of the bridge called *Naumachiaria*, which Tiberius Cæsar directed should be landed and laid in view, as a singular and miraculous monument to all posterity; and it remained entire and whole, until the time that Nero the emperor built his stately amphitheatre. This piece of timber was a larch-tree, it contained in length, one hundred and twenty feet, and was in thickness every way, two feet, from one end to the other." Vitruvius attributes in his time, the decay of the buildings in Rome, to the want of larch timber. Venice is built chiefly upon piles of this wood driven into the marshy ground. And the huts of the peasantry in some parts of Switzerland, in the Tyrol, and Carniola, are constructed of larch, in all which situations it is said to be very durable. The considerable specific gravity of foreign larch has been urged against its general use, but that lately imported into this country, when seasoned, weighed only on an average thirty-eight pounds to the cubic foot.

* It appears by a late survey of the forests in the neighbourhood of Cochin on the Malabar coast, by Mr. Edye the superintendent of ship-building, that the following are the species of timber grown there in addition to the jungle wood.

TEAK,—these trees are marked, and have a saw-kirf through the sap one year, felled the next, and the timber brought down for exportation the third.

ANGELE,—a tree very large in size, is said to be durable when constantly paid over with oil, chiefly used for boats and canoes.

BLACK-WOOD,—chiefly used for household furniture.

BLACK EBONY,—used for cabinet-work.

CEDAR,—red and white, these are chiefly employed by house-carpenters, and called by the natives, Dwedah.

PEON or POON,—considered to be a wood of inferior quality.

strength is much greater, the specific gravity is less than that of English oak. This wood in some cases has been found to be a great preservative of iron; but in others, bolts of that metal when extracted, were found to be nearly destroyed. Many ships have been from time to time purchased into the service, that were built of teak, and their durability is such that no definite period can be fixed. The first ship of the line, built in the East India Company's dock at Bombay, was the Minden of seventy-four guns; this ship was finished and undocked in the year 1810, and although she has been much employed in service, is now in excellent condition; since which period several ships of the line, frigates, and sloops, have been built at that place. In order to have durable ships, and at the same time to give employ to our artificers at home, each ship brings to England a duplicate frame of teak timber, with as much thickstuff and plank as she can conveniently stow.

Saul is employed extensively at Calcutta, in the construction of ships; and although not so much esteemed as teak, yet it is a durable wood: the frame of his Majesty's ship, Hastings, of seventy-four guns, launched from Calcutta in 1818, was constructed thereof.

Sissoo has been also used in building ships; it is not, however, much esteemed for durability.

Poon has been from its lightness sometimes used for the decks of ships, but chiefly for their masts, for both which purposes it is well adapted.

Stink-wood, so called from the disagreeable odour of its juices,

has been imported in considerable quantities from the Cape of Good Hope *; it is much subject to an irregular heart-shake,

* The forests in the neighbourhood of Plettenbergs Bay, at the Cape of Good Hope, were surveyed in the years 1811 and 1812, by Mr. Jones, a shipwright officer belonging to Portsmouth dock-yard, in order to ascertain their resources for naval purposes; the following are the species of trees and their qualities :—

Stink-Wood.—A species of the oak, as it bears acorns, but differing in form from those on the European oaks. There are four sorts, the white, the grey, the red, and the black; they are strong, tough, and hard woods, but the white is considered to be the best. The stink-wood is in general very shakey; this, however, is least in the white, more so in the grey, much more in the red, until in the black, it has what is termed "a spider web heart."

Geel, or Yellow Wood.—The most abundant of all the trees in the forests, there are two sorts, the straight and the antiniquas, the former is the better wood, but that is inferior to fir.

Else, or Alder.—These are aquatic trees; there are two sorts, the red and the white; the former is very scarce, while the latter is extremely plentiful; neither sort is fit for ship-building.

Essen, or Ash.—Two sorts, the red and the white; the white grows to a great size, but either is unlike in character the European ash.

Klip, or Rock Ash.—Very hard and heavy, grows only to a small size.

Yzer, or Iron Wood.—Two sorts, the black and the white; remarkably heavy, and heart shaken: there is great difficulty in working this wood, but although so heavy and close, it is not durable.

Hassegaay.—A hard and strong wood, grows only to a small size.

Saffraan, or Saffron Wood.—A hard, tough, and heavy wood, which grows only to a small size.

Peer, or Pear Wood.—There are three sorts, the hard, the white, and the red; these woods are hard and heavy, inconsiderable in point of quantity, and not good in quality.

Vlier, or Elder.—Small in size, resembling European box-wood.

Swart Bast, or Black Bark—Grows only to a small size; close, and tough in texture, but inconsiderable in quantity.

Swart, or Black Wood.—Very small and scarce; its colour is red, having black spots thereon.

Zyde Bast, or Silk Bark.—Small in size, extremely hard, but very little used.

occasioned either by the soil on which it grows, or by the effect of tempests; this, however, is generally to such an extent, that a plank of four inches in thickness can seldom be cut from the largest trees; added to which it is soon decomposed and subject to the fungus rot. Its further importation has not been encouraged.

Beef-wood, the growth of New Holland, has been brought to

Gomassie.—Small in size, but plentiful, of a yellow colour, very hard in quality, and heavy.

Rood, or Red-Wood.—Very abundant, small in size, heavy, close, and tough, used chiefly for the handles to workmen's tools.

Kouha.—Not plentiful, small in size, of a hard quality, no use is made of it.

Kersen, or Cherry-Wood.—Moderately sized, hard and heavy, most trees rotten at the heart. The roots have the property of burning like candles.

Paarde.—The stems are short, the wood hard and tough, and used chiefly for the spokes of wheels; few trees of this kind in the forests.

White-Wood.—Two sorts; rather soft in quality, something like European beech.

Spik, or Pork-Wood.—The trees are inconsiderable both in size and quantity; the wood is hard, tough, and rather heavy.

Benken, or Beech.—Very scarce and small in size, tough in quality, and in grain, resembles English beech.

Wilde Kastanie, or Wild Chestnut.—The timber is of a white silvery colour, but the trees are very scarce.

Keur-Wood.—The trees are small, generally growing on the skirts of the forests, the wood of a spongy quality.

Olyven, or Olive-Wood.—May rather be called a bush than a tree, the wood splits easily and is of no value.

Melk, or Milk-Wood.—This wood is hard, tough, and heavy, the trees are small in size, but compass in growth.

Saly, or Sage-Wood.—Inconsiderable both in size and quantity.

All the trees which have been enumerated are evergreens; and for the purposes of ship-building, the stinkwood alone is valuable, but it is not plentiful in those parts of the orests where it can be removed without much difficulty.

this country in small quantities, and used chiefly for bulkheads and ornamental work in the cabins of ships.

From the many specimens of African timber which have been imported from Sierra Leone, four have been selected for the construction of ships, *viz.*, Turtosa *, (by some called African teak) Linshinginara, Conta, and Koa; only the first, however, in large quantities; although there is at present no reason to doubt their durability, yet sufficient time has not elapsed, (as they have been imported only within the last six years,) to speak of it with confidence.

The timber grown in Prince of Wales's Island, has also been employed in building of ships; the Malacca frigate, of thirty-six guns, was constructed there in the year 1809; this ship was unserviceable in June 1815, and taken to pieces in 1816: the frame, which had been converted from poon and quala moda timber, was in a very defective state; the beams which were of

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* The following are the native names of the specimens sent to this country.

Turtosa	Kelill	Catessy
Tolonsa	African Almond	Lowland box-wood
Bomia	Bombury	Singalinganarah
Cooper	Pissiman	African pine
Koa	Black-oak	Highland box-wood
Conta	Whismore	Lingawoora
Roth	African Cedar	Cobooso
Wassomar	White Woossmah	Brimstone
Tumo	Cronko	Bessy
Buckham	Linshinginara	Mulberry
Tapercucanico	Blue Woossmah	Mangrove
Motto, the vegetable butter-tree.	Awoora	
	Mammy apple	

teak were sound, the knees were of oak, and the planking of oak and teak; the oak was in a state of decay. This experiment proving so unfavourable, no more ships have been built at this island.

From different parts of America, large quantities of timber have been from time to time imported, and particularly that of the growth of Canada*. Since the year 1763, when at the general peace the possession of this territory was confirmed to the British government, there has been a constant desire to assist the colony by purchasing timber; and as early as the year 1772, considerable quantities of oak plank were imported for

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* Canada produces the following trees which are more or less used in works of architecture:

Oak, white
—— red
—— black
—— blue or swamp

Birch, black
—— white
—— yellow

Elm-rock
—— swamp

Ash, blue
—— white

Cherry-tree
Walnut-tree
Hickery
Bass-wood

Beech, common
—— blue or swamp

Pines, red
——— yellow
——— white
——— spruce
——— hemlock
——— tamarisk, or larch

Maple, curled
——— birdseye
——— soft
——— rock or sugar

Cedar, white
——— red

Iron-wood

the use of the navy; experience, however, proved it to be so inferior to the Dantzic plank, that the demand was lessened, and its use gradually discontinued. In the year 1807, when, in consequence of what were termed the Berlin and Milan decrees, the continent of Europe was shut against British commerce, large quantities of oak, and red and yellow pine-timber, were imported from Canada. The use of these woods, however, contributed very much to the early decay of his Majesty's ships; for it was found that when the white oak was cut into plank and placed on their bottoms, it would not last for more than five years *, and its decay on decks and topsides was even earlier.

Independently of the employment of the red and yellow pine timber on the repairs of ships, fifteen frigates were built of the red, and three of the white pine, during the years 1814 and 1815; the average durability of the former, was three years and a half, that of the latter, rather less than three years.

Pitch-pine, the growth of North and South Carolina and Georgia in the United States, has also been imported; this has been extensively made use of on ships, and in the years 1813 and 1814, seven frigates were constructed of this timber; their average durability may be considered to be about six years and a half.

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* The planks of the bottom of the Devonshire of seventy-four guns, which ship was launched in September 1812, were cut from the best kind of American white oak timber that could be procured; and although this ship had not been employed at sea, they were found to be totally decayed in February 1817, when she was taken into a dock for repair.

In order to make trial of the several sorts of wood grown in the neighbourhood of Halifax, a sloop of war, called the Halifax, was constructed there, and launched in October 1806; this vessel was unfit for service in April 1812, and taken to pieces at Portsmouth, January 1814; she was built of birch, red-pine, and oak; the birch, particularly in those situations moderately dry, and pine, were found to be totally decayed; and the oak, although in rather a better condition, was still in a decaying or decayed state.

In the year 1796, the cedar of Bermuda, commonly called pencil cedar, was first tried in the construction of ships of war; since which time eight sloops, twelve cutters, and eighteen schooners have been built for his Majesty's service at that island; the cedar in question is found to be a light, very durable *, but weak wood, and appears to be well adapted for building small light vessels.

Mahogany, from the Bay of Honduras, has lately been supplied for building ships; the beauty and durability of this wood is so well known in the common articles of household furniture, that it need not be insisted upon in this place. Some timber, called Santa Maria, has also been imported from the same place;

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* The ancients were well aware of the durability of cedar, and its noxious qualities to insects; Pliny, in his 16th Book, 39th Chap., says, "This virtue has the oil of cedar, that if any other timber be anointed therewith, it is not subject to be injured by worm nor moth, nor yet to be rotten." Horace alludes to its preservative properties when put on papyrus, in his *Ars Poetica*:—

> ———At hæc animos ærugo et cura peculi
> Cum semel imbuerit, speramus carmina fingi,
> Posse linenda cedro, et lævi servanda cupresso?

it is a wood of open grain, but sufficient time has not elapsed to speak of its qualities with certainty.

The durability of the Portuguese ships built at the Brazils*, and the offer of that government, shortly after their emigration from Europe, to allow the exportation of timber, caused the introduction of several sorts into England; these have been used on ships of war, without complaint having been made of their want of durability; the supply, however, has been lately interrupted.

Having given an enumeration of the different sorts of wood which have been used in the construction and repairs of his Majesty's ships, with their comparative durability, as far as it can be ascertained, it remains to be stated, in conclusion, that strength has generally been considered the principal feature of good timber; although this, no doubt, is a consideration of moment, yet durability is the quality which renders it most valuable. Ships, when first constructed, have a great superabundance of strength; this is necessary in order that they may possess it in a

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* Mr. Hawkes, assistant to the master shipwright of Deptford-yard, surveyed, in the years 1811 and 1812, several of the forests in the Brazils; and from the specimens brought to Europe by him, and the descriptions given, the following species of timber were selected by the British Government:

Mangalo	Grabu	Goruculy or Gorandi
Grasalie	Paroba Vermilla	Grapia--punha
Olio	Paroba Amerella	Gratumba
Tapinhuao	ParobaBranca	Gratumba Amarilla
Olio Cabareira	Aia	Guisilica
Secupira	Arririva	Secupira Amarilla.
Mazaranduba	Carvalho	

sufficient degree after the deterioration that they necessarily undergo from age, defects, or accidents. Viewing the subject, then, in this light, the property for which timber is chiefly to be prized, in works of art, is durability.

THE END.

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